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Construction Engineering
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April 1995

The Reviewer's Assistant System: System Design Analysis and Description

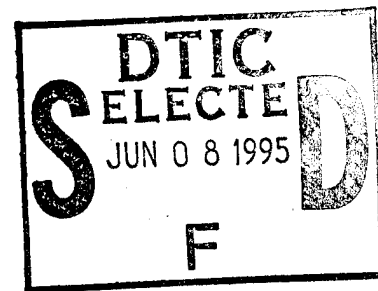
by

E. William East, Timothy L. Roessler, Mark D. Lustig, and Michael Chin-Ming Fu

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There are three benefits of using the Reviewer's Assistant. First, the Reviewer's Assistant can help users conduct high quality design reviews in less time. Second, users can apply past experience from previous design reviews. Finally, the design reviews will be saved for future benefit.

This report discusses the design decisions that were made during the system development process and how they were implemented in Version 0.9 of the Reviewer's Assistant. It also describes possible future enhancements to the system. An unattached Appendix B contains the list of a roofing review analysis used in the system development.



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Foreword

This work was conducted for the Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers (HQUSACE) under Project 4A162784AT41, "Military Facilities Engineering Technology"; Work Unit SA-AW4, "Reviewer's Assistant System." The HQUSACE technical monitors were Stan Green, CEMP-CE, and Hugh Adams, CEMP-ES.

The research was performed by the Facility Management Division (FF) of the Infrastructure Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was E. William East, CECER-FFC. Michael Golish is Acting Chief, CECER-FF, and Alan Moore is Acting Chief, CECER-FL.

The authors would like to recognize the contributions of Thomas Napier as a prior principal investigator on this project. Mr. Napier also compiled the low-slope roofing data used in the model-based system discussed in this report. The authors would also like to recognize the contributions of Thomas Mahon, who provided one of the C language computer code libraries that is used in this system. Peter Robinson should also be recognized as one of the original programmers who, with Mr. Mahon, developed the first prototype of the current system.

Prior to the authors' work on this project, Jeffrey Kirby, Maria Tupas, and Gregory Bridgestock provided essential initial work in the area of design reviews.

LTC David J. Rehbein is Commander and Acting Director of USACERL, and Dr. Michael J. O'Connor is Technical Director.

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1 Introduction

Background

Construction personnel can contribute to the design of U.S. Army Corps of Engineers projects in three valuable ways when their input is made part of the design process. First, they can improve the overall quality of design documents in the areas of Biddability, Constructibility, and Operability (BCO). U.S. Army Corps of Engineers projects have a minimum of two design reviews, one at the concept stage and one at the final design stage. BCO reviews are conducted as one portion of an overall design review (Engineer Regulation [ER] 415-1-11 1988, p 1). The goals of BCO reviews are to identify:

1. Problems related to errors, omissions, and inconsistencies that would keep contractors from bidding on a project.
2. Inappropriate construction methods and materials that would increase construction costs.
3. Components and building systems that would result in facilities difficult to maintain and operate.

Second, construction personnel can help reduce costs. According to a Construction Industry Institute (CII) study conducted in 1986, the Army and Air Force can reduce the cost of major construction projects by 6 to 23 percent with increased construction input to design documents (*Constructibility: A Primer*, 1986, pp 1-11). While CII's savings projections may be optimistic, even a small percentage decrease in overall construction cost would result in significant savings.

Last, construction personnel can help identify environmental compliance issues. Overlooking these during the design phase may cause delays or even stoppage of construction projects, or may cause a completed project to be unsuitable for its intended use. Increased construction input in the early stages of design may reduce the costs associated with construction delays.

The research described in this paper represents the latest step in a continuing commitment by Headquarters, U.S. Army Corps of Engineers (HQUSACE) and the U.S. Army Construction Engineering Research Laboratories (USACERL) to improve

design quality by incorporating the experience of construction professionals. This effort began with an analysis of the process of constructibility reviews at the Corps of Engineers (Kirby et al. 1989). As a result of this analysis, the Automated Review Management System (ARMS) was developed (*Automated Review Management System, User Manual* 1990). ARMS provides a platform for the exchange of design review comments between all members of a project team, and is required to be used for designs of all military program projects (ER 1110-1-12 1993).

Objective

The objective of this research was to identify methods to improve the efficiency of construction personnel who conduct design reviews. If possible, the efficiency of reviewers across organizational boundaries was also to be considered. Once improved methods were identified, a prototype system would be developed and tested. This prototype would operate within the following constraints: limited availability of computing power at many construction field offices, difficulties in data communication between Corps Area/Resident Offices and Field Offices, integration within existing computing systems and environment, and practical considerations regarding work flow within and between offices.

Approach

The approach of the study described in this report was to evaluate computer system applications to find a computer programming paradigm that matched as closely as possible the process followed when personnel conduct BCO and other types of design reviews. Studies that followed the development of ARMS have suggested that rule-based "expert" systems would be an appropriate technology upon which to build a design quality review system (Kirby et al. 1991). However, a demonstration rule-based system that had been developed at USACERL and tested at the Norfolk District Area and Resident Office was not well received by design reviewers. An object-oriented (model-based) system was considered infeasible. Next, a case-based reasoning (CBR) system was developed. It was originally named "the Biddability, Constructibility, Operability, and Environmental compliance (BCOE) Advisor"; later it was renamed "the Reviewer's Assistant" to reflect its wide audience.

The Reviewer's Assistant benefits design reviews in several ways. Because users from all levels of experience will be able to browse through and apply comments from past reviews, reviews will become more comprehensive. An analysis program that abstracts lessons learned from comments allows users to apply past experience from previous

design reviews, and saves current projects' lessons for future use. Additionally, the Reviewer's Assistant should allow reviews to be conducted more speedily, allowing a single reviewer to "cover more ground" without sacrificing the quality of the review.

Mode of Technology Transfer

This work is available electronically through a variety of sources selected to provide the widest possible distribution. The system is available through anonymous ftp transfer via ftp.cecer.army.mil. The files are located in the asce/ra subdirectory. The files are self-extracting zipped files: "program3.exe" contains the system; "manual.exe" contains the user's manual. The program is also available through the "General Engineering" Library of CompuServe's "Engineering Automation" Form and through CivilNet at (406)449-5633.

2 System Design Criteria

This chapter provides the rationale for the Reviewer's Assistant's design and identifies constraints placed on the system. The first section of this chapter lists the constraints within which the system needed to be designed. The second section discusses the results obtained during a requirements analysis phase of the project. The third section describes the technological paradigm upon which the system is based, case-based reasoning. The final section discusses the scope of the system design in the context of factors that distinguish successful software systems.

System Constraints

The constraints within which the Reviewer's Assistant needed to be designed were:

1. The system must be able to be programmed, maintained, and used on an 80286 processor IBM AT-compatible computer.
2. The system must be able to input information to and receive information from ARMS.
3. The system must take into account difficulties in data communications between offices (bad phone lines and lack of modems); thus, although ARMS is the primary means of distributing review comments, it must also be possible to print and fax them.
4. The system must be compatible with the work flow within and between offices.

Requirements Analysis

Requirements analysis is the term used for the process of analyzing the potential benefits and pitfalls of the project under study. Designers of any system must use input from potential users, along with their own insight, to accurately predict what will and will not be needed in the new system. An accurate requirements analysis is critical for successful system development, and documenting the result of this analysis is important both for an historical record and for use by those attempting to expand the system.

An important part of the requirements analysis phase of this system was an in-depth investigation of the existing procedure for conducting BCO and other design reviews. The developers concluded that the design review process involves the following steps:

1. The reviewer examines the plans and specifications for a project.
2. Drawing information from past experience, from standard references, or from other advisors, the reviewer notes design errors or omissions found.
3. The reviewer writes a list of review comments to be sent to the designer and shared with other reviewers.

This three-step process is represented schematically in Figure 1.

Based on the analysis of this process, the developers determined that it would be important during the design and development of the Reviewer's Assistant to keep in mind the design review issues listed in Table 1.

Evaluation of Knowledge-Based System Techniques

Knowledge-based systems include rule-based systems (also called expert systems) and object-oriented systems. The type of object-oriented system deemed most applicable was the model-based system.

Rule-based systems. Initial reports indicated that rule-based expert systems would be appropriate for development of systems to improve design reviews (Kirby et al. 1991). The authors began by reviewing rule-based expert system approaches.

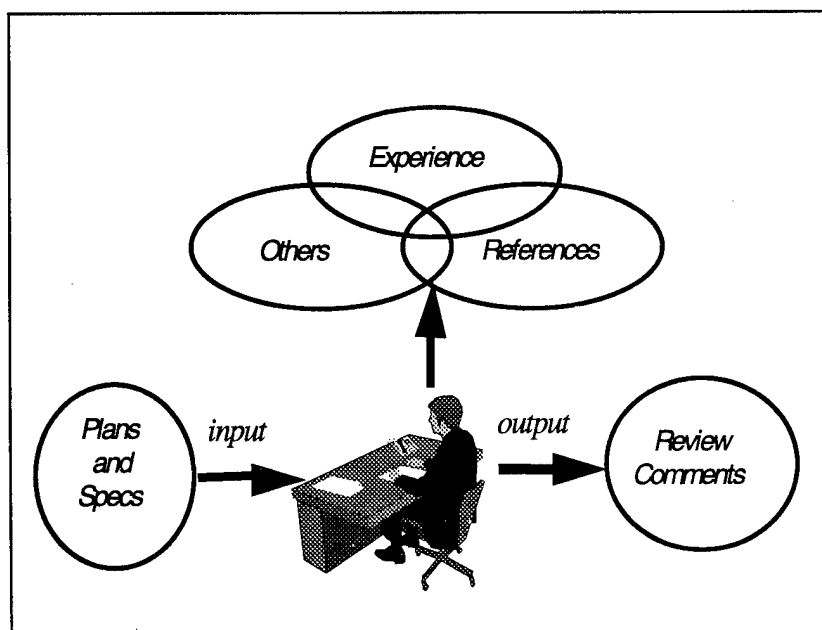


Figure 1. The design review process.

Table 1. Important issues in the design review process.

1. Design reviews are conducted on a set of plans and specifications as a method for identifying and correcting possible design deficiencies before construction begins.
2. Design reviewers generate "review comments" that describe the deficiencies and may provide a method for avoiding the deficiencies in future designs.
3. The same design deficiency is often found in many different projects.
4. The earlier a design deficiency is discovered and corrected, the greater the cost savings. The use of "expert opinions," therefore, in the concept stages of the design would be of considerable value.
5. Current methods of design review do not provide for efficient searching and retrieval of past review comments.
6. Design review personnel should be able to identify potential problems based on specification sections and other meaningful indices.

Rule-based systems process information based on knowledge formulated in decision trees. Sets of if-then statements are chained together to form large sets of rules to meet the goal of the system (Vassilou et al. 1983). Rule-based systems operate in one of two modes. The first mode occurs when a large set of initial data is used to derive the critical characteristics of that data set, a process called forward chaining. The second mode occurs when a rule-based system attempts to prove a goal by selectively evaluating specific conditions. This is referred to as a backward-chaining system. In both forward and backward chaining, computer memory (random access memory [RAM]) contains information about the current state of the problem, the required ultimate state that must occur if the problem is to be considered solved, and a prioritized list of rules to be evaluated.

Theoretical evaluation of the application of rule-based expert systems to design review resulted in the determination that a rule-based paradigm would not be effective. While rule-based systems have been successful for diagnostic applications, using rules to assist in developing design review comments was determined to be ineffective.

A significant problem with rule-bases for this application is that they tend to be relatively static systems based on a set of fixed assumptions about the type of information available and user responses. Because projects with related design review comments are unique, rule-based systems would have to be frequently updated. Updating requires significant work by skilled programmers. Reviewers would also be required to assist these programmers in identifying new and revised rules and in testing the revised system.

In addition, user feedback on a demonstration prototype test of a previous rule-based system was not encouraging. It was determined that the system would be too complicated for practical use because of the excessive number of rules to be followed.

Additionally, a rule-based system did not appear to allow use of detailed review comments.

Object-oriented systems. A more powerful type of knowledge-based system is called an object-oriented system. In the object-oriented system, information is contained in sets of related data, called frames; this information may be either data or knowledge about how to manipulate that data. In contrast to a rule-based system, which must be activated by user command, the object-oriented system may use small program modules called "demons" or "methods" to activate rules depending on the status of various components within the system, without having received specific user commands.

The use of object-oriented techniques for design review was found to be inappropriate for development at this time. To create an object-oriented system for use in design reviews would require development of a detailed computer model of every building system and of how the different systems interact with each other and with a project environment. This was determined to be implausible given the initial project time, funding constraints, and hardware constraints (the software is to be programmable, testable, and deliverable on a 80286 PC-based platform).

Even though an object-oriented system was not considered a currently feasible base for design review tools, model-based techniques could be included after development of an initial prototype based on a different automation paradigm. This was felt to be the best approach to a long-term development effort.

Case-Based Reasoning Approach

The approach ultimately selected to develop the Reviewer's Assistant is called case-based reasoning (CBR). CBR is described as:

...it is the job of a case-based reasoner to have a library of cases; a method of storing new cases that allows them to be found again when needed; an indexing scheme that reflects processing that has gone on while a case was initially considered; a method of partial matching that allows new cases to be considered in terms of similar ones; and a method of adaptation that allows information garnered from one case to be applied to another (Riesback 1989, p 24)

This description proposes four main parts to a CBR system: (1) a case representation, (2) an indexing mechanism, (3) a storage and retrieval mechanism, and (4) a method for case adaptation.

Case Representation

As in the development of any model of reality, the issue of representing the situation in a way that effectively conveys the important information is key to the development of a CBR system. Representation may be understood as “defining the terminology of the domain and gathering representative examples of problem solving (cases) by the expert” (Barletta 1991, p 24). The cycle of CBR, as given by Riesbeck and Schank (1989, p 32), is shown schematically in Figure 2.

Case representation in the Reviewer’s Assistant is based around the *components* of a project that are to be evaluated in a given design review (Reilly et al. 1992). The most essential of these components are the *features* and *values*. In the Reviewer’s Assistant,

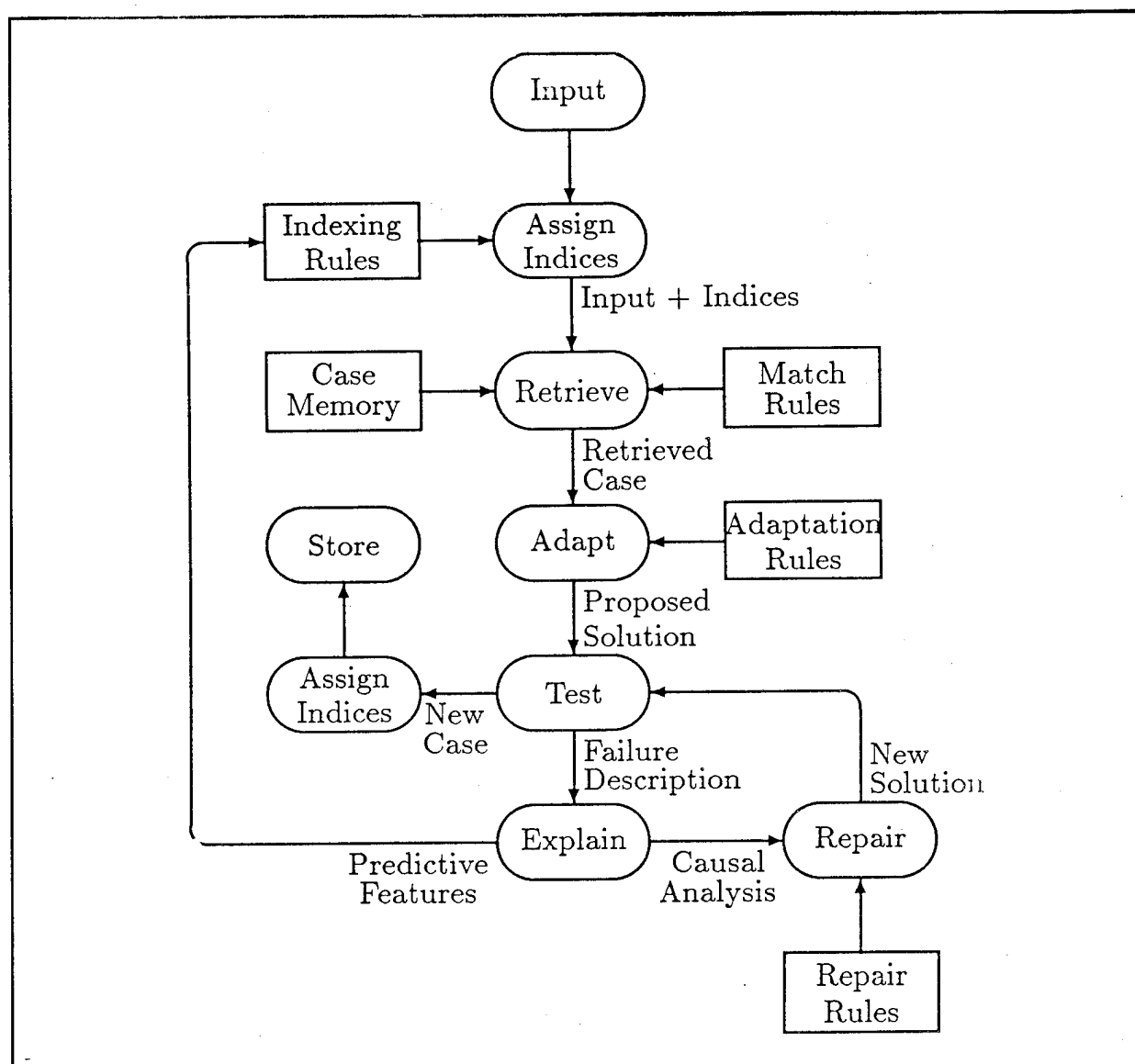


Figure 2. The case-based reasoning process.

the features are the specification sections and the values are the paragraphs, or sub-sections, of each specification section. Each feature-value combination identifies a distinct category of construction work.

Indexing

The CBR system's power lies in its ability to capture critical information about each review comment and index the information to assist in relating similar data. Comments are indexed according to a set of specification sections, and by reviewer, site criteria, and other categories of information. Each of these categories is contained within hierarchical structures. The user determines which categories of information are relevant, and the system uses the database indices to relate information from the user to similar data.

Storage and Retrieval

The next important aspect of any CBR system is the method of storage and retrieval. CBR is especially appropriate for design review because a typical method employed by reviewers is to rely on projects completed successfully in the past. While people may forget the specifics of a successful past outcome, they typically remember the significant constraints on development of a solution. Also memorable are those factors that caused failures in the past. Allowing people to retrieve information based on factors that are familiar to them may be a powerful paradigm to support a wide range of knowledge workers.

The Reviewer's Assistant data is stored in a system of tables in the relational database management system, RBase. The hierarchical nature of the RBase data is essential to the storage and retrieval of information. For further discussion on the use of RBase tables as the storage and retrieval mechanism of the Reviewer's Assistant, refer to Chapter 3, **System Data Structure and Design**.

Case Adaptation

The final feature of CBR employed in the Reviewer's Assistant is a method of case adaptation. Case adaptation involves entering data involving the current situation (project). Once the user has entered the desired data, the program searches the case "library" to find similar cases. The user may then decide which of the program's library selections are appropriate to the situation at hand.

Factors Affecting the Success of New Software

A recent study by Spoonamore et al. (1991) measured technical employees' response to the introduction of new software. The Spoonamore study indicates that, in general, successful use of the software may be predicted by the answers to the following questions:

1. After installation does the software allow the user to quickly use the information in the system?
2. Does the software provide some small tangible benefit or attempt to solve large problems?
3. Is the user able to interact with a system in a way that the user has experienced with other software systems?
4. Does the use of the software allow the user to use the system in increments of capabilities?
5. Does documentation explain how to accomplish specific tasks for which the user is responsible?
6. Are there mentors who will assist coworkers to learn additional system skills?
7. Does the software support standardization within the organization?

(Spoonamore et al. 1991, p 17).

The answers obtained when applying each of these questions to the Reviewer's Assistant are discussed in this section.

Scope of System Design

The answers to the first two questions are based on an incremental system development approach. A system must be easily installed and quickly produce meaningful results if it is to be accepted for general use among an organization's technical staff. Only after a system has been accepted may additional features be added to enhance the system's performance and capabilities.

While software designers must have a vision for a complete system with components that might include such items as automated links to other organizational elements and the use of artificial intelligence techniques, an incremental design and development approach enforces specific and timely goals. The succession of these goals produces a good control cycle for the project. At each point in the cycle the system's users are able to evaluate the goals and further refine the system requirements. This frequent user feedback ensures that large sections of computer code will not need to be rewritten (Kameny et al. 1989, pp 6-7).

One formal model of this product development cycle has been referred to as the *spiral model* (Boehm 1988). In the spiral model, shown in Figure 3, there are four steps for each phase of a project. The first step of the cycle is to determine the objectives that a system is to meet. In addition, alternatives and constraints to system development are considered. In the next step, system developers evaluate the objectives in light of the alternatives and constraints while attempting to maximize the system benefits. The developers then provide the results of their work to the system users for evaluation. In the early stage of the project the material to be evaluated may be system concept documents or project proposals. In later stages of the project users typically evaluate specific prototype system implementation. During the third step of the spiral model, detailed design requirements are developed. The plan to implement these design requirements is developed in the final step of the spiral model.

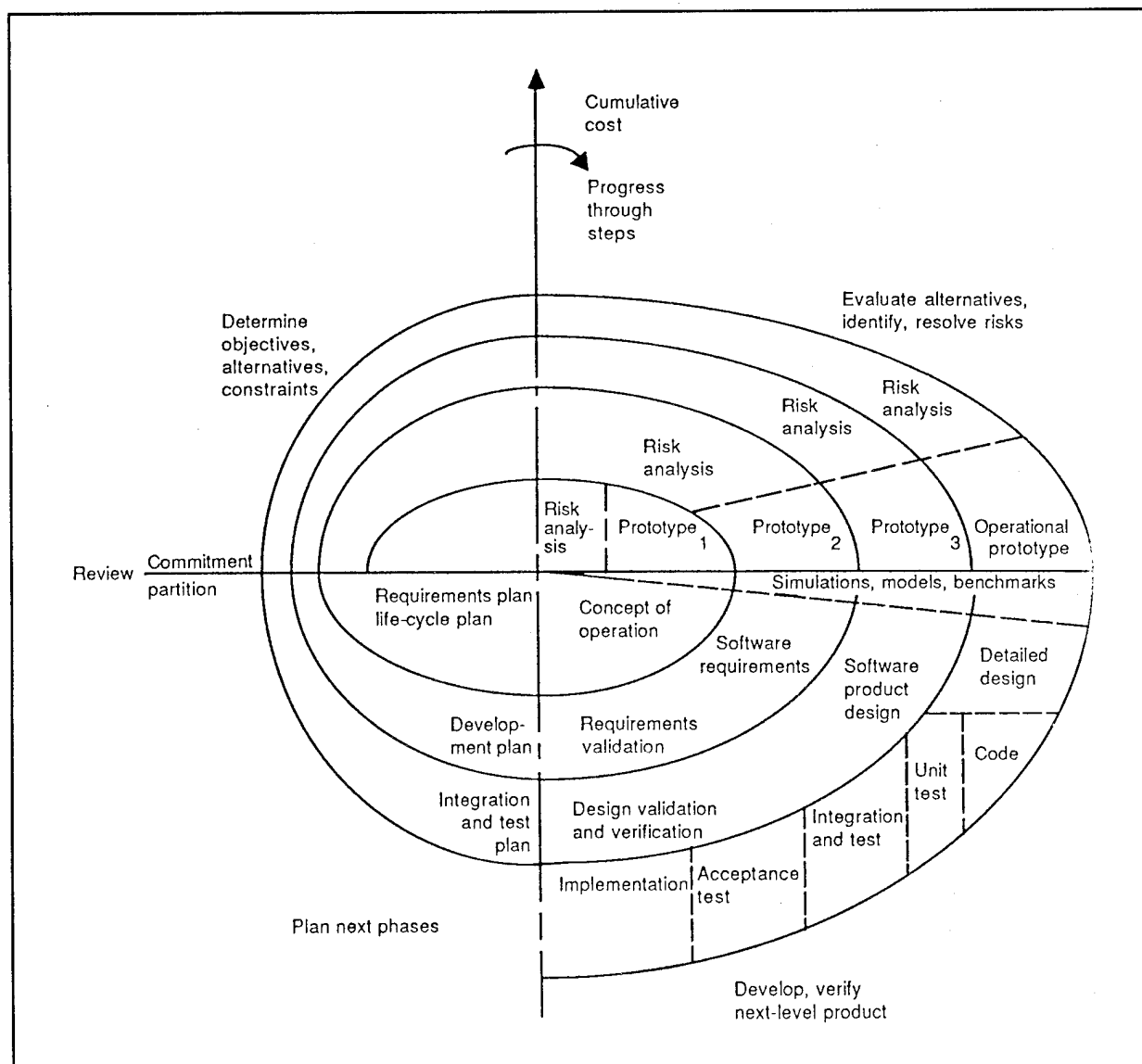


Figure 3. Spiral model of product development.

During development of the Reviewer's Assistant System, the development team followed a spiral model with several interim products being shown to a single user or group of users. The questions that were raised at each user group meeting were: (1) Does the information shown accurately reflect the task to be accomplished? (2) Does the interaction of the user with the system reflect the steps required to accomplish the task? and (3) Does the output of the system accurately meet the requirements and objectives?

Once a system was developed that generally met the needs of the primary technical proponents, the system was shown to other potential system users for review. The process of incremental development and feedback with the user groups was essential to the development of a system that allows users to quickly and efficiently meet primary job responsibilities.

Simple User Interaction

The next question that should assist developers to design a useful system is the following: "Is the user able to interact with a system in a way that the user has experienced with other software systems?" The Spoonamore study found that if a user was unaware of what to do next, then the user would try steps that the user has successfully used with other software. Since personal computer (PC) users are generally accustomed to using Microsoft Windows, the program was built to reflect the basic graphical interface contained in the Windows system. This interface allows program selections to be made by holding down the ALT key on the computer keyboard and pressing the first letter of the function to be selected.

Users of other software platforms such as Macintosh were also considered in the development of the Reviewer's Assistant. Since the mouse is a typical mode of user input for the Macintosh platform, the system was designed to allow use of a mouse.

Incremental System Use

Another factor considered important to a successful system, according to the Spoonamore study, is that a system should be designed to allow users to incrementally increase their use of the program. The Reviewer's Assistant was built to allow users four different levels of use of the system.

The first level of use is a structured method called the *menu-driven* mode. When the program is operated in this mode, there are step-by-step instructions which guide the user through the essential steps in a design review. Online help screens are available for every situation. A status line at the bottom of the screen allows users to keep track

of their progress through the program. The status line provides users with a list of each keystroke available in the current screen. A typical menu-driven mode screen is shown in Figure 4.

The second level of use, called the *user-driven* mode, allows users to perform each of the functions in the menu-driven mode, such as retrieving and creating new comments, with much more flexibility. This level is primarily for those users who are experienced enough with the operation of the Reviewer's Assistant not to require the extra assistance provided by the *Menu-Driven* mode. They operate the program by making selections from the top-level menus *File*, *Edit*, *View*, and *Print*.

The initial training period, system documentation, and frequency of use are important to allow users to quickly reach the second level of use. A typical screen from the user-driven mode is shown in Figure 5.

The third level of use of the system involves using the functions of the *System* top-level menu (Figure 6) to make global changes to the data. Users at the third level, who

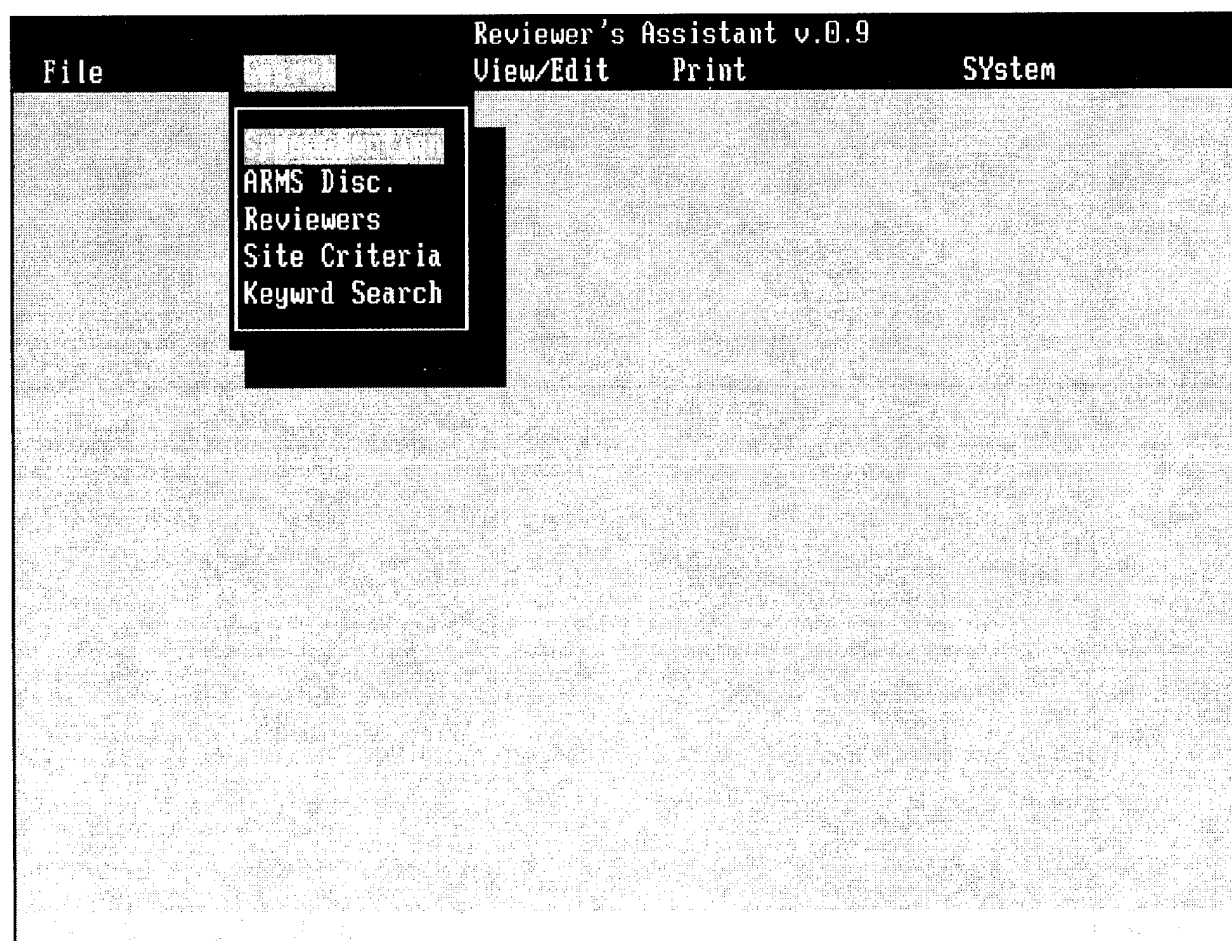


Figure 4. Typical screen of menu-driven mode.

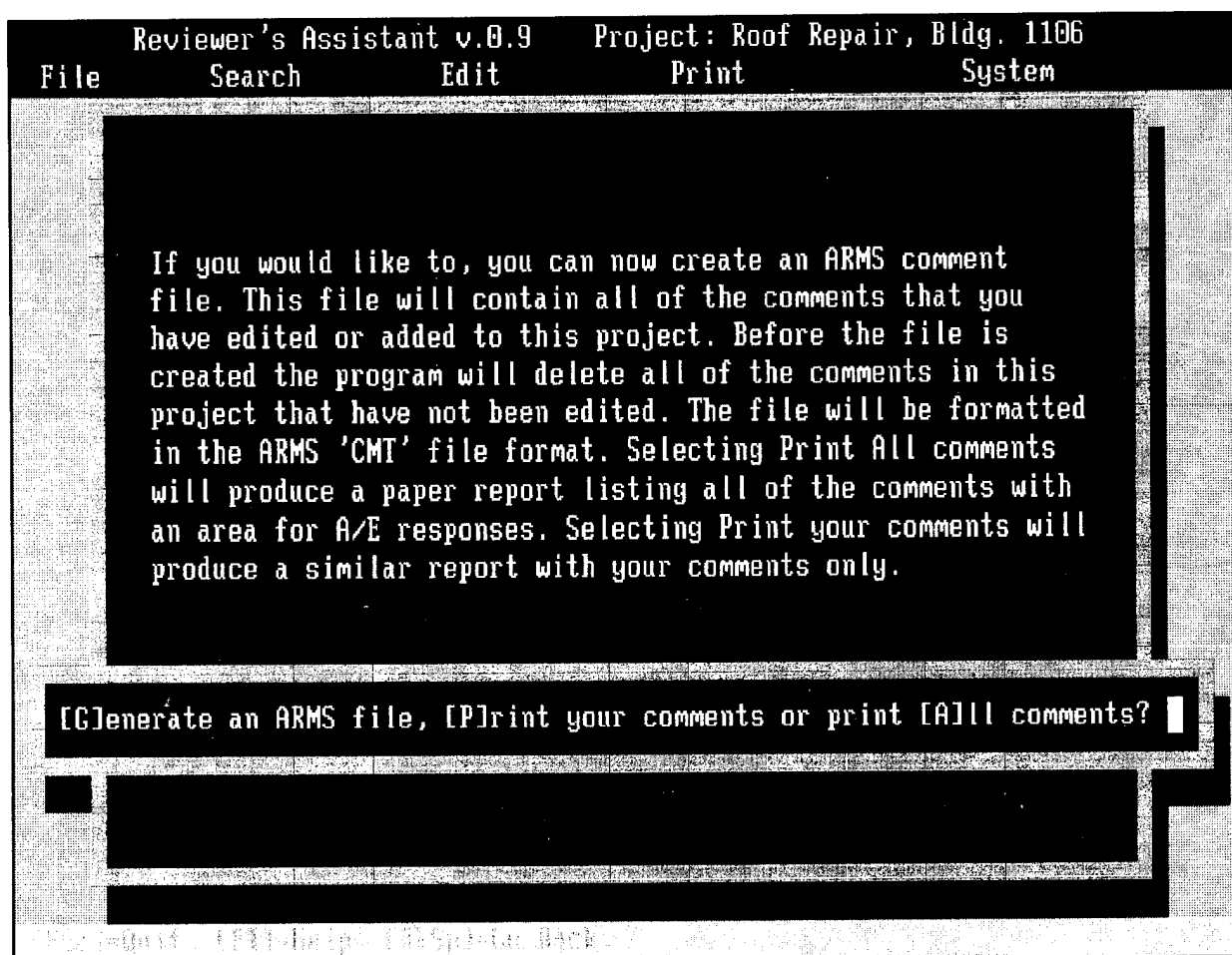


Figure 5. Screen from user-driven mode.

could be called system supervisors, will have more extensive training in Reviewer's Assistant than the two groups already discussed and will be knowledgeable enough to add or change some of the choices that other users may make when using the program. They will use the System menu to add or edit specification sections, site criteria, reviewer, ARMS discipline, and other criteria.

The last level of use of the system is for those users who are knowledgeable in the use of relational database systems and, specifically, the use of Microrim Corporation's product RBase. (RBase is the database management system used in the Reviewer's Assistant system.) These users, who may be called system administrators, are able to use Rbase to manipulate data in the Reviewer's Assistant database, in order to maintain and revise the database.

Documentation

While good software should be intuitive enough that users need not read a manual, any system that attempts to solve real problems must have adequate documentation

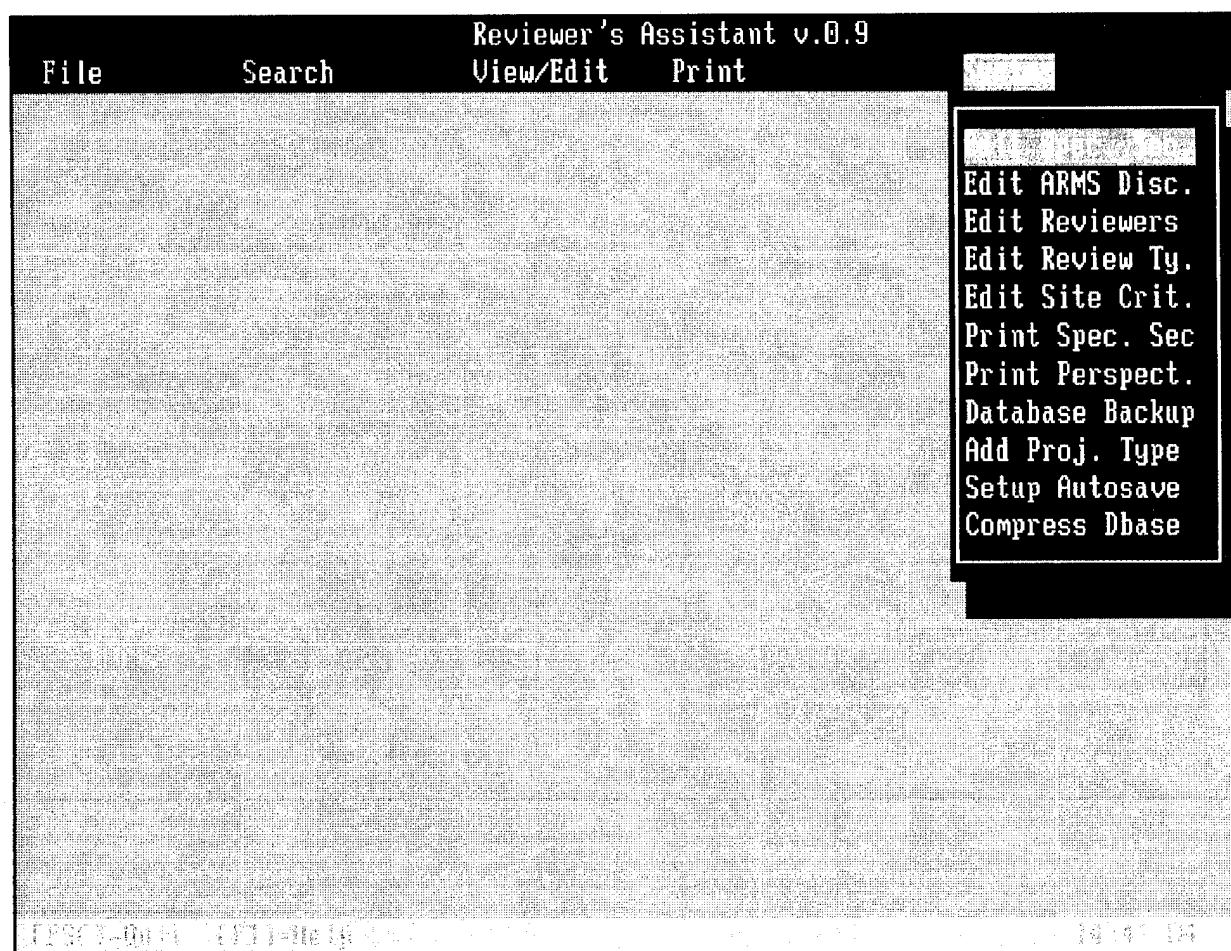


Figure 6. The System menu.

to describe the system's use and function. Question five from the Spoonamore study discusses documentation: "Does documentation explain how to accomplish specific tasks for which the user is responsible?"

Discussions with user groups indicated that the user manual should be structured in a task-oriented fashion. In contrast to traditional reference manuals that describe the function of each of the system's features, a task-related manual describes how to use the system to complete specific tasks. The user manual for the Reviewer's Assistant guides the reviewer through the menu-driven mode to conduct a sample design review.

Ultimately, users will put all computer manuals on the shelf. For this reason, it was decided that a Quick Reference card would benefit users. This card schematically describes the use of the system, step by step. It also contains information on communication software and basic DOS commands. The portion of the Quick Reference card that describes the Reviewer's Assistant is shown in Figure 7.

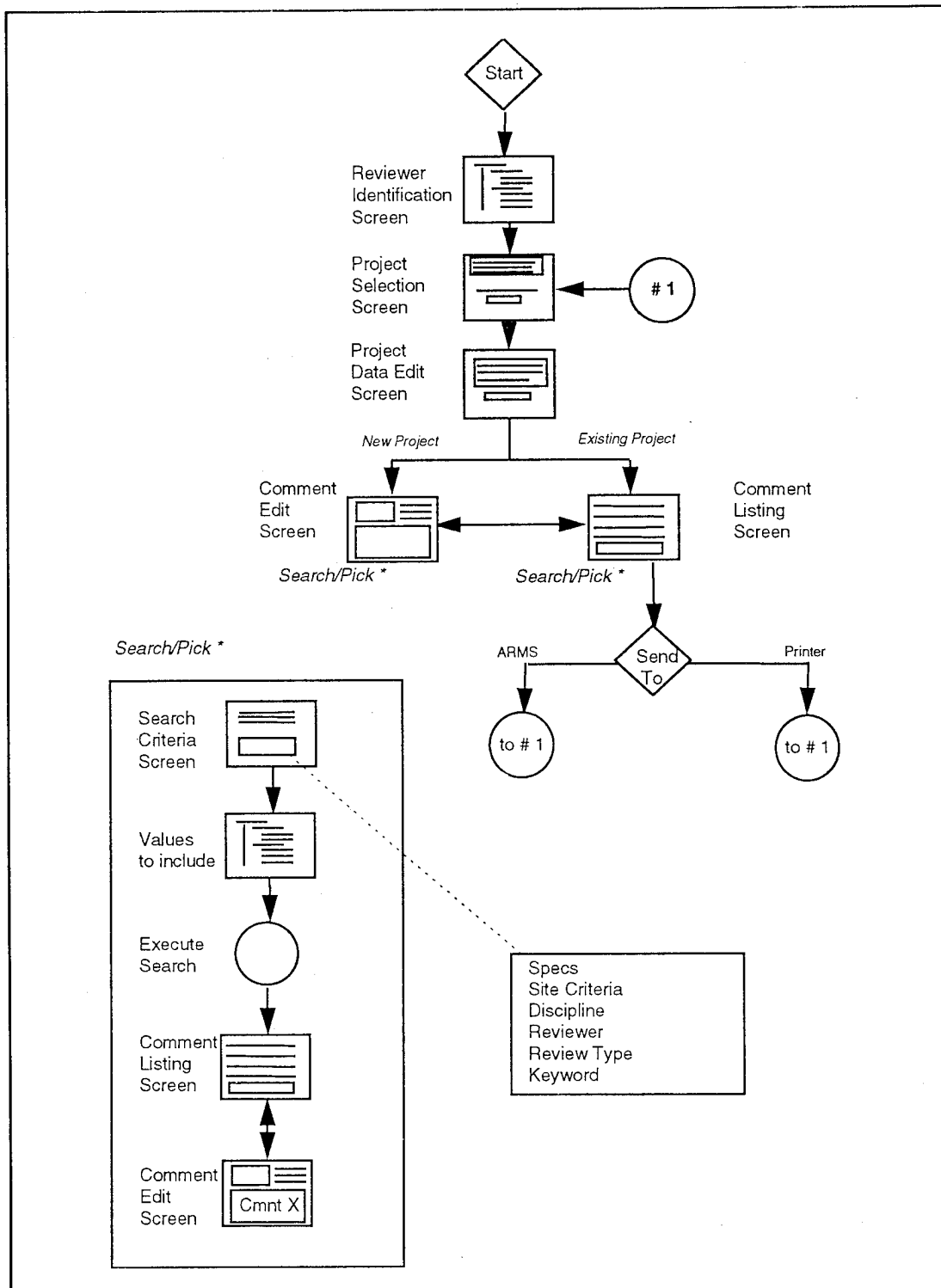


Figure 7. Quick reference card schematic of Reviewer's Assistant operation.

Training

The next question from the Spoonamore study discusses training: "Are there mentors who will assist coworkers to learn additional system skills?"

A prototype of context-sensitive online help/computer-based training for the Reviewer's Assistant was developed for the 1994 ARMS Conference. There were many requests for copies of a completed version. Development of a completed version depends on future resource availability.

A problem to be expected in the development of any training program for a computer application is that many employees have not received training on the general use of computers. Basic computer training requires employees to be willing to learn and use the new technologies, and employers to provide courses for employees and an environment where employees are able to take the necessary time to learn and use the new technology. Once the basic training has been accomplished, the time needed to learn how to use the Reviewer's Assistant should be no more than 2 hours for each employee or group of employees trained.

Organizational Integration

The final issue addressed in the Spoonamore study is: "Does the software support standardization within the organization?" This question may be broken into two: (1) Does the software support integration among the users of a system? and (2) Does the software allow information from one system to be easily transferred to other systems? The ways in which the Reviewer's Assistant supports organizational integration are discussed in this section. The following section discusses the standardization of the data systems involved in the Reviewer's Assistant.

Organizational integration is supported by the program's ability to support "remote databases." A group of users may be comprised of personnel with different areas of expertise. If one member of this group needs information about an unfamiliar subject, information from a central database may be brought into the user's database.

Another aspect of the Reviewer's Assistant that is important to integration within organizations is the fact that the structures within the program are fully customizable after delivery. Using the *System* menu of the program, the types of projects and specification sections may be changed. Reviewer names and site-specific criteria may also be changed to support the needs of an individual office.

Finally, the training that accompanies the software supports organizational integration. Developers designate a single point of contact for each new user group introduced to the Reviewer's Assistant. The developers hold training meetings with the points of contact to ensure that they in turn are able to act as trainers for local personnel.

Data Systems Standardization

The Spoonamore study found that a key indicator of a system's potential for success is its ability to support data standardization. Data standardization allows information from one system to be transferred to other systems without retyping the data. Given the number and complexity of data systems within large organizations, the staffs of these organizations would be changed from technical professionals to key-punch operators if systems didn't support data standardization. Ensuring compatibility of Reviewer's Assistant data was one of the most important tasks facing the system's developers.

Integration with ARMS. The first means by which the Reviewer's Assistant system supports data standardization is its compatibility with ARMS. ARMS is a network connecting reviewers and designers to a central computer (*Automated Review Management System* 1990). It allows review comments to be managed in such a way that they may be stored and transferred between designers and reviewers as shown in Figure 8 (Kirby et al. 1991, p 11).

When a comment is generated using the Reviewer's Assistant, the user is prompted to enter all information required for export to ARMS. The ARMS discipline, specifi-

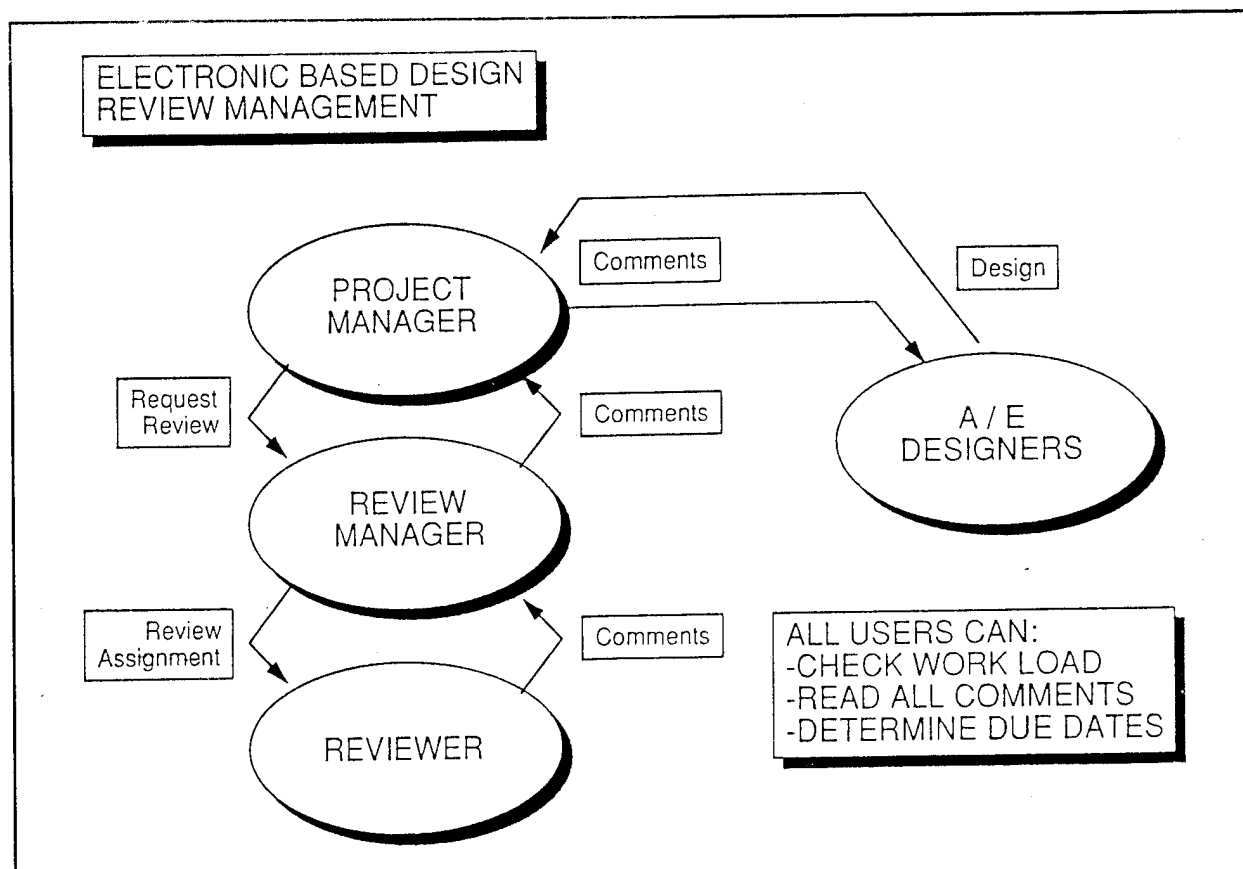


Figure 8. ARMS flow chart.

cation number, and sheet and detail numbers are highlighted in red on the screen, indicating to the user that they must be filled in before attempting upload to ARMS. For export (upload) to ARMS, comments must first be translated into the correct format. The format, called the *CMT file* because ".cmt" is appended to the file name, is shown in Figure 9 with two sample ARMS comments. Comments in this format can, with one phone call, be input to ARMS.

Users can also import Reviewer's Assistant comments in the CMT format. With this import capability, users may take existing ARMS comments and load them to "seed" their own Reviewer's Assistant databases.

Use of CERS, ER 1110-1-12 data. The second means by which the Reviewer's Assistant system will support organizational integration is through transfer of Construction Evaluating Reporting System (CERS) data and data from Engineer Regulation (ER) 1110-1-12.

CERS data is composed of HQUSACE inspections reports from various U.S. Army Corps of Engineers projects around the world. These comments furnish the Reviewer's Assistant with a useful base of data. This base will provide users with an initial foundation for current use, to make the Reviewer's Assistant an important tool. The nearly 400 CERS comments included in the Reviewer's Assistant database and listed in the Appendix of this report were selected from a total pool of 5,817 available

```
.PROJINFO1:Roof Repair Bldg 1106  
.PROJINFO2:5321  
.Name:Craig Grebeck  
.Office:CECER-FFA  
.CmtDate:12/31/99  
.ARMSPROJECT:0  
.ARMSNUMBER:0  
.REVNUMBER:0
```

```
.Location:07600  
.Discipline:  
.COMNTNUMBER:1
```

Specifications permit the use of exposed galvanized steel sheet metal with prime and finish painting. This type material is not permitted by cegs 07600 and the extra labor cost involved in initial surface treatment and continuing maintenance more than offset the cost of meeting present criteria. Future similar designs should follow cegs criteria with respect to the use of sheet metal material selection.

```
.Location:07600  
.Discipline:  
.COMNTNUMBER:2
```

Per the plans, two downspout nozzles for the rainwater leaders on the back side of the building are located ten feet above grade. Unsightly stains have already developed on the exterior wall finish where water falls down the wall. Consider attaching a bronze drip chain from the downspout nozzle to the splash block. It could be anchored to the splash block to direct water away from the wall.

Figure 9. Example ARMS CMT file.

comments. Comments chosen were design related and were made before October 1, 1990.

The comments in the CERS database are suited extremely well to the Reviewer's Assistant. The CERS comments are generally well stated; problem, cause, and remedy are presented, and the relation of the comment to the specific construction category is easily identifiable by specification number. For example, the comments shown in Figure 9 are comments that were directly transferred from CERS into the Reviewer's Assistant.

The data from ER 1110-1-12, *Engineering and Design Quality Management* (1993), comes from the checklists in the ER's Appendices. These checklists were imported into the Reviewer's Assistant as comments, to serve as general guidelines for design reviews. Only those items that apply to Reviewer's Assistant issues were imported.

Both the CERS and ER 1110-1-12 data are stored in the Reviewer's Assistant as "Lessons Learned" projects. This designation means that comments (data) from these projects may be found on searches, copied, and applied to new projects, but may not be edited.

Exchange of lessons learned. An additional benefit of the Reviewer's Assistant's data compatibility is that sets of comments may be shared between reviewers or offices. For example, a commander could provide a list of all requirements on any future project. Site-specific criteria can be organized and distributed across all agencies working at a specific location. Through the exchange of "master lists" of lessons learned, new reviewers may gain and easily use the experience of others.

Chapter Summary

During development of the Reviewer's Assistant, a requirements analysis was performed to determine what capabilities the system should have in order to be useful. Appendix B (unattached) contains the complete list of the roofing review analysis. With the information gathered from this analysis, the developers studied various knowledge-based systems, including rule-based and object-oriented systems, to determine which would provide the best system given the constraints placed on development. Case-based reasoning was finally selected as the paradigm that would best support the system desired.

Following the recommendations of the study by Spoonamore et al. (1991), the authors developed the Reviewer's Assistant so its chance of being accepted and used in the field soon after development would be as great as possible.

3 System Data Structure and Design

Data within the Reviewer's Assistant is stored in the commercial database system RBase. RBase was selected because at the time that the Reviewer's Assistant system was being developed, it was the only PC platform database system that supported American National Standard Institute's (ANSI) Standard Query Language (SQL). The data is stored in an SQL-compatible system, and the Reviewer's Assistant program was written in the C programming language.

Reviewer's Assistant data is contained in three files: RA1.RBF, containing the definition of the structure of the database, RA2.RBF, containing the data itself, and RA3.RBF, containing the indices to the columns of the RBase tables. The database is developed by separating related data into different tables. Indices link the information contained in these tables. There are 14 tables used in the Reviewer's Assistant system. Table 2 lists these tables and a brief description of their contents.

This chapter describes how the database system in the Reviewer's Assistant was designed and how it is used to model the data needed to conduct and distribute design reviews. The first major section below describes some of the important functions and features of relational database tables. The second discusses the important components of the Reviewer's Assistant tables and the links between the tables. The closing major section addresses some limitations on the design of the system.

Functions of Relational Database Tables

Each relational database table contains different sets of information for use in the Reviewer's Assistant. Relational database tables, such as those found in RBase, are essential to the Reviewer's Assistant program for the reasons described below.

First, these tables allow the program to keep the definition of the data apart from its application. The data application is kept in a table, or tables, separate from the definition, which is a much smaller amount of information. In the RBase tables, the

Table 2. Rbase tables used in the Reviewer's Assistant.

Table Name	Function or Contents
FEATURES	Table of all features. Each feature has a name and an identification number.
FVALUES	Table of all values. Each value has a name, identification number, and a single feature parent.
FPARENT	Links features to their parents.
PERSPECT	Table of all perspectives. Each perspective has a name, identification number, and a parent.
LASTALL	Acts as a "placeholder" for the data counter.
MENU DRIVEN	Contains text for screens in menu-driven mode.
NOTES	Table of the text of all comments. Each body of text is linked to a project identification number and a comment number.
PROJCMNT	Links projects and comments.
FCMNTS	Links a comment and its feature-value combinations.
PERSCMNT	Links a comment and its perspectives.
PROJECTS	Contains information about each project, such as name, ARMS project number, project location, review date, and ARMS export filename.
CMNTFIELD	Links a comment to its location information in the plans and specifications.
KEYWORDS	Table of all keywords. Each keyword is linked to a unique keyword identification number.
KEYCMNT	Links a comment to its keywords.
COMMENTS	Lists the comment numbers that have been used.

"definition" of the data is simply an identification number. To find the data's application, the program searches the list of defining numbers and, when the relevant identification number is found, uses that number to find the desired information (the application) in other tables.

This separation ensures that the user need only remember words (such as specification or paragraph names, or key words) for the data, and not identification numbers. The tables link the information that is most convenient for the user, the words, with the information that is most easily handled by the computer, the identifying numbers.

An example of the separation of data definition from data application is the storage of a design comment. In one table, the comment text is stored along with the comment

identification number. In other tables that contain information about comments, only the comment identification number is listed.

A second purpose of relational database tables in the Reviewer's Assistant is to ensure that a change in data in one place in the database will impact other data only where appropriate. This means that if an attribute of a design comment is changed, that change need only be performed in one place. For example, if a comment is copied for reuse on a project, and the text of the comment is modified, this only affects one table. The structure of the database indices, and therefore the database integrity, is not changed.

Reviewer's Assistant Data Structure

The following three sections will describe the contents of the Reviewer's Assistant database tables and how these tables are used in the program. The first section describes the attributes and function of the review comment. The second section, **Representing the Classification Tree**, and its subsections discuss the method of classification of the other important items in the Reviewer's Assistant database. The third section describes the links between the comments and the classification scheme.

Representing Review Comments

Because the final products of design reviews are review comments that discuss design deficiencies and perhaps furnish solutions to these design deficiencies, the most important element in the Reviewer's Assistant database is the review comment. The remaining data exists only to assist in the classification, storage, and retrieval of the review comments.

A comment functions not only as a note on a design deficiency pertaining to a specific project, but also as a more general concept, an *idea* that can be used in similar situations on other projects. When a review uncovers a design deficiency that is already addressed in the database in the form of a comment, the comment can be applied to the new situation by retrieving the comment and modifying it as necessary. The text and other attributes of the comment may be changed for a new project, but the underlying idea of the comment will remain.

In the Reviewer's Assistant database, a comment's application to a specific project and its general idea are kept in separate locations. The NOTES table tracks a comment's application to a specific project. It contains (1) the text of each comment, (2) its

associated comment identification number (explained in the following paragraph), and (3) the identification number(s) of the project(s) to which the comment applies.

The COMMENTS table lists an identification number representing the idea or issue addressed in the text of the comment. Regardless of the number of times an idea is used for different projects, the idea of that comment has only one identifying "comment number." For example, if comment number 64 from Project 1 is copied for use on Project 2, a new comment number is *not* created in the COMMENTS table, but a new note is created in the NOTES table.

The project-comment table, named PROJCMNT, holds the key index between project and comment numbers. Each time an idea is applied to a project, a new entry is created in the PROJCMNT table.

Figure 10 shows how the link between a comment's text (contained in the NOTES table) and the comment number (contained in the PROJCMNT table) is maintained as a comment is copied to a new project and modified. The example shows how a comment is used on a project where two downspouts are present and then reused on a project with four downspouts. As shown in the figure, when the comment is copied to a new project, a new entry is made in both the NOTES and PROJCMNT tables, but the COMMENTS table is unchanged.

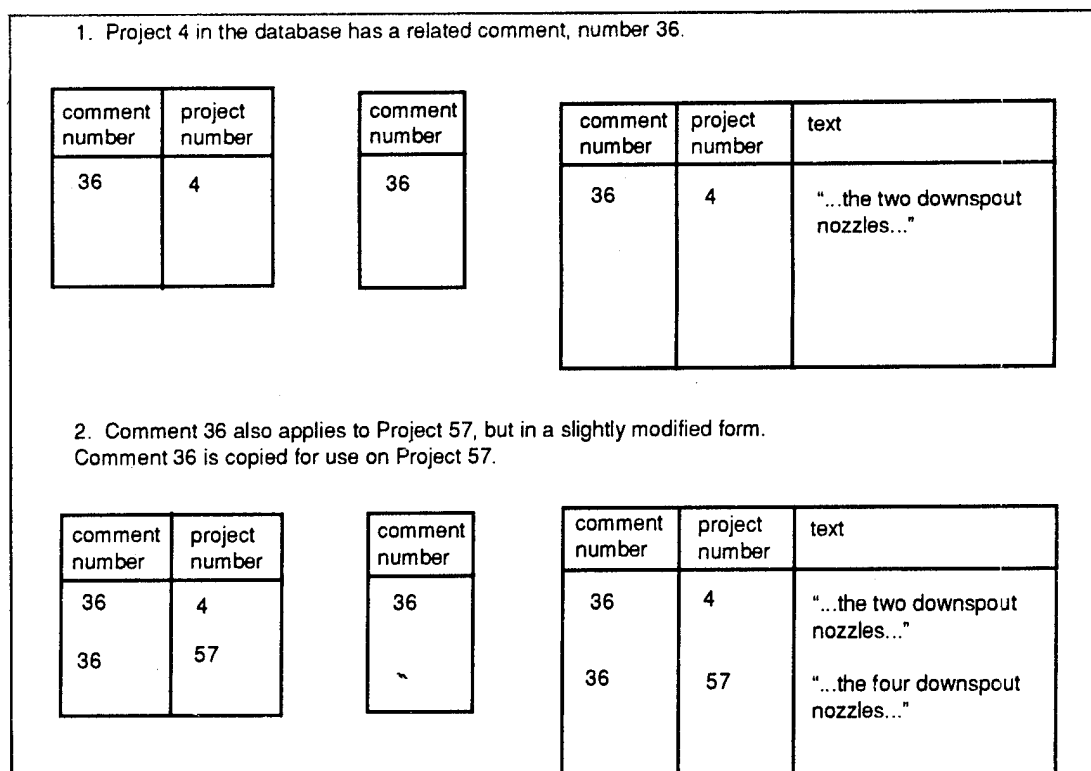


Figure 10. Effect on tables of Comment reused.

Representing the Classification Scheme

One of the most important functions of the Reviewer's Assistant is its ability to search for and reapply comments to current situations. Reviewers encounter unique situations on almost every review, and the ability to search for comments based on different properties of the design is essential. The previous section discussed the simplest method by which comments are classified: according to the projects on which the comments are used. The reviewer may wish to search for comments based on other, more specific attributes. The following paragraphs of this section describe the means of classifying comments in the Reviewer's Assistant: the feature-value and perspective "trees," and the keywords.

The Feature-Value Tree. In a typical design review, one would commonly want to search based on specification sections and paragraphs of these specification sections. Consider, for example, a reviewer examining plans and specifications for a roof design. If an issue concerning the skylights arises, the reviewer may wish to search for comments based on the specification section "Thermal and Moisture Protection," and the paragraph "Skylights," among others. This type of search is made possible by the use of a hierarchy of features and values, or a feature-value tree, for comment classification. In the Reviewer's Assistant, *features* are specification sections and *values* are the paragraphs contained in these sections.

The features are recorded in the FEATURES table by name and number. The feature-value tree, or the relationship between the specification sections and their paragraphs, is recorded in the FPARENT (feature-parent) table. Each feature number is listed along with its immediate parent feature, which allows the "tree" of features to be generated.

Each feature is listed with a corresponding value in the FVALUE (feature-value) table. Figure 11 demonstrates the interaction between the tables FEATURES, FVALUES, and FPARENT. "Thermal and Moisture Protection" is selected as the specification section (feature) and "Flashing and Sheet Metal" is selected as the paragraph (value).

Figure 12 shows a portion of the feature-value tree as it appears in the program. One branch of the feature-value tree, the "Thermal and Moisture Protection" category, is shown with each of its subcategories (paragraphs).

Although features are always specification sections and values are always paragraphs in the Reviewer's Assistant examples illustrated here, users are not restricted to this. The feature-value hierarchy and combinations may be changed according to each

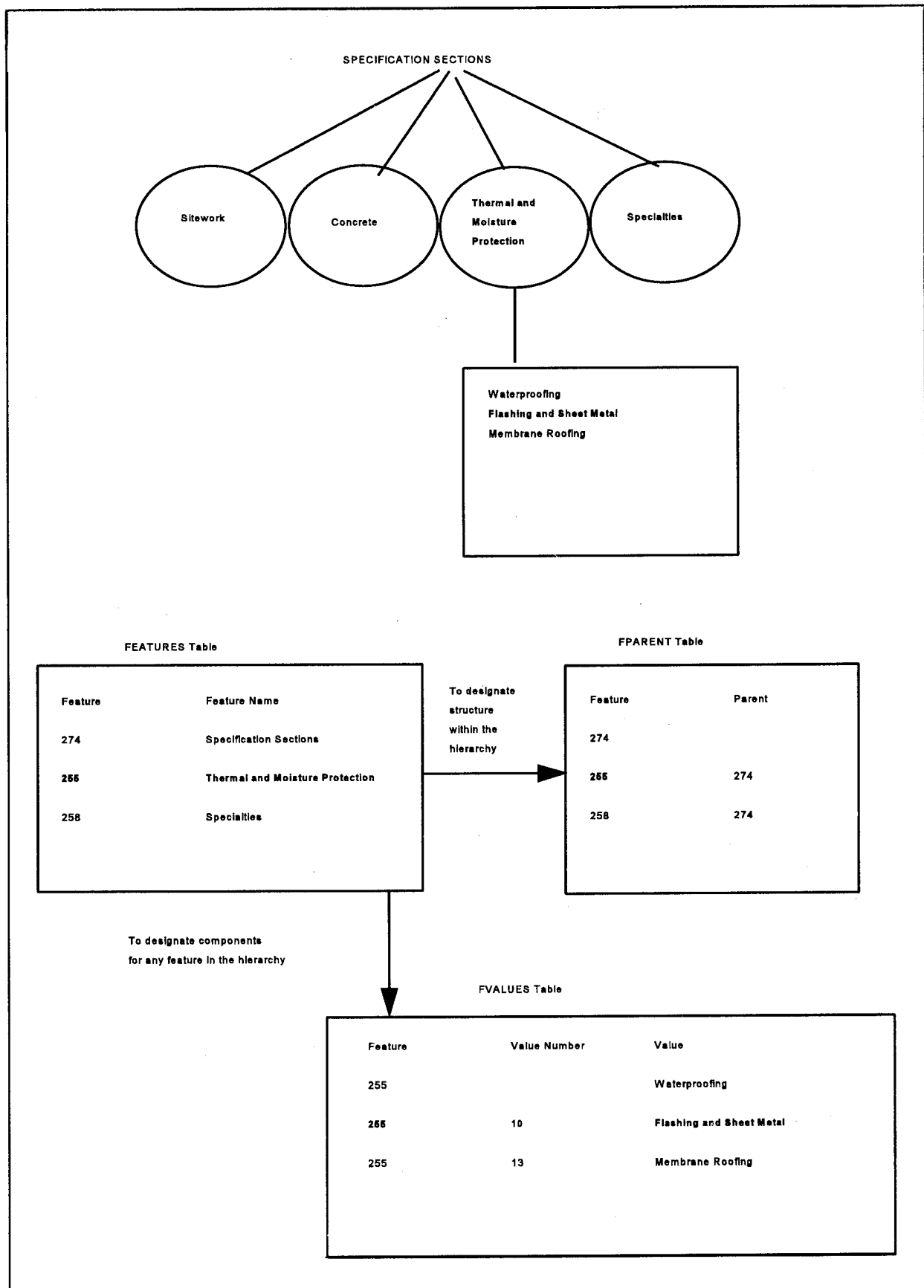


Figure 12. Feature-value tree schematic.

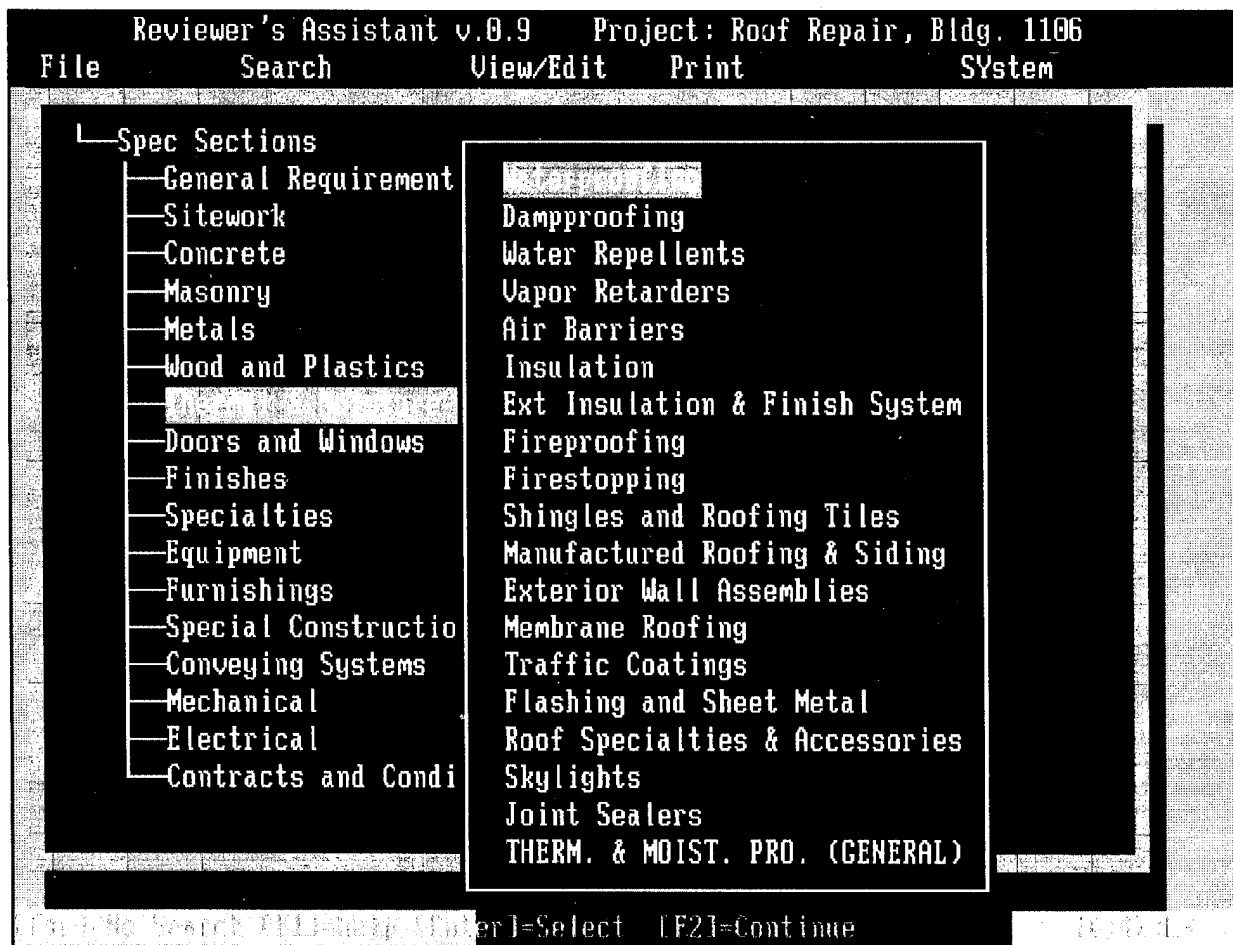


Figure 12. Feature-value tree on screen.

user's needs. Features and values may be added, edited, or deleted as desired, allowing for a very flexible data structure.

The perspective tree. The reviewer may wish to search for comments based on attributes besides the feature-value combination. A situation may arise where a search specific to certain site criteria, an ARMS discipline, a review type (for example, 35% Concept Review), or specific reviewer may be more valuable. The Reviewer's Assistant allows for these types of searches based on a hierarchy, or tree, of perspectives. The Reviewer's Assistant perspectives are unique sets of information about the projects and comments.

The tree analogy applies to the perspectives in a fashion different from the feature-value tree. The perspectives (the top level category) themselves are of interest to the user. This differs from the feature-value tree, where the value (the subcategory) is of interest, and the higher levels of the tree are merely a way of reaching it.

The structure of the perspective trees gives the perspectives the necessary flexibility for use of the system. The users' manual of the system explains how to customize the perspective trees. For example, an office can set up the site criteria selections to suit their needs, creating a site criteria perspective tree like the example shown in Figure 13.

An office that used this example tree would be able to search for comments based on the following criteria: *Champaign, Illinois, Corps of Engineer Projects and HUD Projects*, among others. Additionally, intersections of site criteria may be used to perform a more targeted search. For example, a search may be performed for comments on HUD projects in Danville, Illinois.

ARMS discipline as a perspective identifies who is most likely responsible to address the design issue raised in the comment. For example, placement of an electrical panel would come under the Electrical Consultant discipline. Placement of an air handling unit so that there is enough clearance for maintenance belongs in both the Mechanical and the Architectural disciplines.

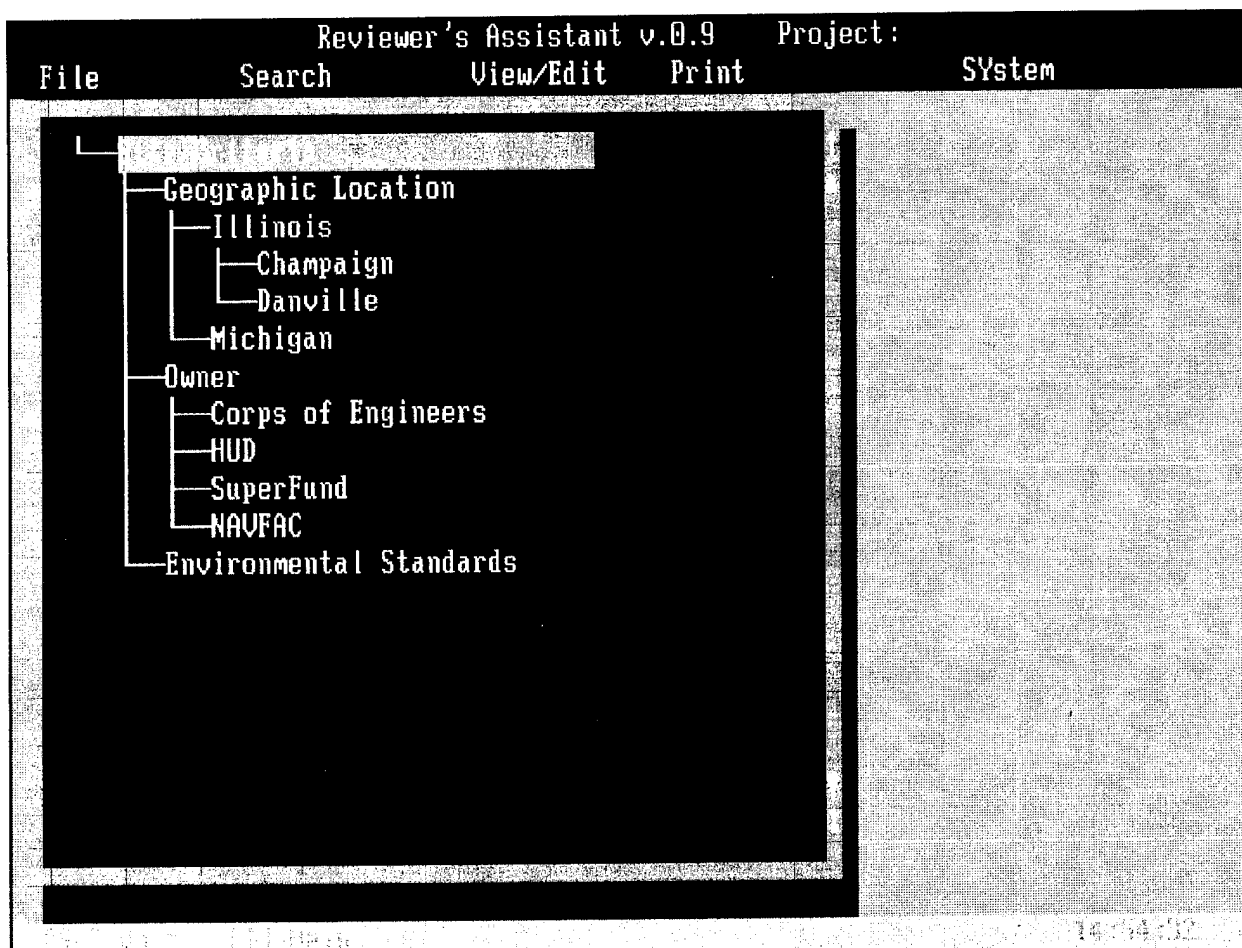


Figure 13. Example perspective tree.

The table PERSPECT holds each perspective's name, identification number, and its immediate parent perspective. Listing the immediate parent perspective allows the perspective tree to be generated.

The perspectives used to classify comments in the current version of the Reviewer's Assistant are: reviewer, ARMS discipline, site criteria, and review type. These four perspectives were identified as the minimum set of data necessary to effectively create, search for, and send comments to ARMS. There are, however, many other perspectives that could be applied to the comments contained in the Reviewer's Assistant. The structure of the perspectives tree is such that the user may use any set of perspectives necessary.

Examples of other perspectives that could be applied to review comments (see Table 3) are discussed in a study conducted by Purdue University (Lutz and Hancher 1988). In this study, additional perspectives that could be used to classify design review comments were the Time of Defect perspective, which indicates the stage of a project

Table 3. Other perspectives used in reviews.

Time of Defect

- Preconstruction
- During construction
- After construction, operational life
- After construction, at start-up
- After construction, within 2 years of start-up
- After construction, later than 2 years after start up.

Biddability Effects.

- Yes or no answer.

Constructibility Effects.

- Yes or no. If yes, effects may include:
 - Excessive cost
 - Structural deficiency
 - Schedule delay
 - Rework
 - Safety
 - Contract disputes.

Operability Effects.

- Yes or no. If yes, effects may include:
 - Facility disruption
 - Energy inefficiency
 - Diminished habitability
 - Structural deficiency
 - Excessive maintenance
 - System replacement
 - Safety detriment.

when a problem is likely to occur because of the defect, and the Biddability, Constructibility, and Operability Effects perspectives, which indicate the impact (if any) the defect will have on these aspects of the project. A general discussion of the application of these perspectives to design review may be found in the American Society of Civil Engineers (ASCE) *Journal of Management in Engineering* (Lutz and Hancher 1990).

Keywords. The ability to classify, and search for, comments based on keywords in the text of the comment allows the user to perform a search on a very specific data set. The keyword set in version 3.0 of the Reviewer's Assistant was taken from the Key Word Index from CSI's Masterformat, 1988 edition (Construction Specifications Institute 1988). This keyword list is also used by the Reviewer's Assistant spellchecker. The keywords and their identifying numbers are listed in the table KEYWORDS. Users may not add or modify keywords.

Linking the Comments to the Classification Scheme

Now that the use of the comment and the classification scheme of the Reviewer's Assistant have been discussed, this section illustrates how the comments are related to the classification scheme.

Feature-value-comment link. Most comments are associated with at least one specification section. To record this in the program, the comments have a link to the feature-value tree. This link is established by assigning each comment the appropriate feature-value combinations in the table FCMNTS. Each link between a comment and feature-value is a row in the table. The link ensures that the feature-value combinations associated with the comment are "tied" to the comment. Therefore, whenever the feature-value combinations to which the comment is linked are retrieved, the comment number is also retrieved.

The linking of the comments to the features in the hierarchy is shown in the figures below. The link is shown schematically in Figure 14, where the tables called into action at each stage are listed to the right. Figure 15 shows the link in the context of the program (see item [F4] at the top of the screen). Both figures show a comment linked to "Thermal and Moisture Protection" (feature) and "Flashing and Sheet Metal" (value).

Perspective-comment link. Besides being associated with the feature-value tree, a comment may also be related to one or more perspectives. The comments must, therefore, have a means to link to the perspective tree. This link is established in the

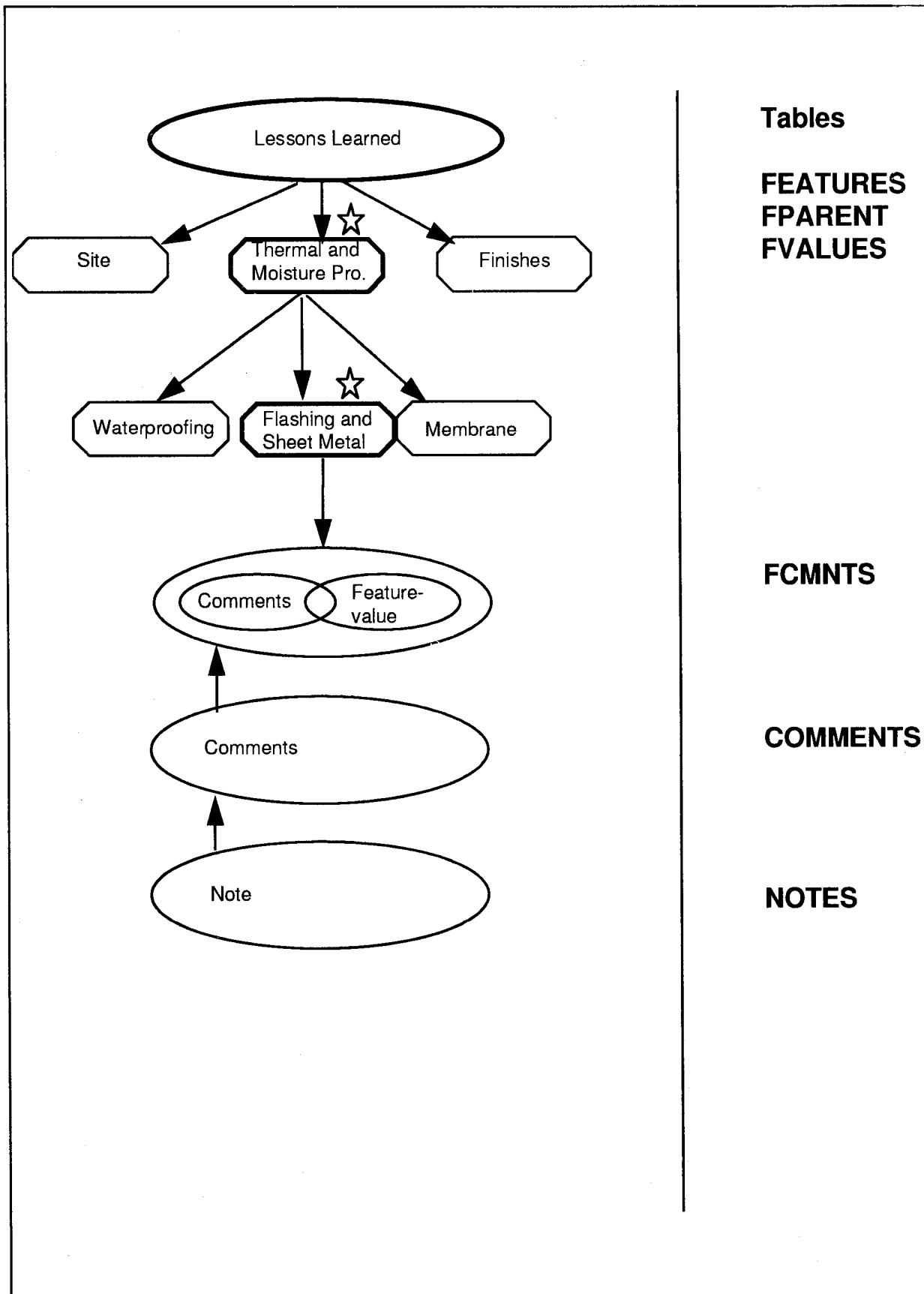


Figure 14. Feature-value-comment link schematic.

Reviewer's Assistant v.0.9		Project: Roof Repair, Bldg. 1106	
File	Search	View/Edit	Print
		SYstem	
[F3] to Edit:		[F4]= Spec.: Flashing and Sheet Metal	
Spec # : 07600		[F5]= ARMS Disc.: Structural +	
Detail # :		[F6]= Reviewers: Bob Chesi	
Sheet # :		[F7]= Review Type:	
Room # :		[F8]= Site Criteria HUD Housing	
		[F9]= Keywords: Galvanized Steel	
<p>Specifications permit use of exposed galvanized steel sheet metal with prime and finish painting. This type material is not permitted by cegs 07600 and the extra labor cost involved in initial surface treatment and continuing maintenance more than offset the cost of meeting present criteria. Future similar designs should follow cegs criteria with respect to use of sheet metal material selection.</p>			
<p>12 of 10</p>			

Figure 15. Feature-value-comment link on screen.

PERSCMNT table, where the comment identification numbers are listed with their related perspective numbers.

The relationship between perspectives and comments is shown in Figure 16. In addition to being linked to a user-created project (Project B) and a Lessons Learned project (CERS Comments) in the PROJCMNT table, the selected comment is also linked, in the PERSCMNT table, to an ARMS discipline, a reviewer, and a site criterion. These links are also shown in Figure 15, a screen from the program, in fields [F5], [F6], and [F8], respectively.

Comments must be linked to the ARMS information (specification number, sheet number, detail number). This data (along with the ARMS discipline) is the necessary data for loading a comment into ARMS. This link exists in the table CMNTFIELD, and is shown in field [F3] in Figure 15.

Keyword - comment link. A comment may also be related to between one and six keywords. The link between comments and their keywords (shown schematically in Figure 16) is established in the KEYCMNT table where comment identification numbers are listed along with their associated keywords. The user has the option of allowing the program to "suggest" a number of keywords. The program simply scans the text of the comment and displays a list, shown in Figure 17, of all words found that are contained in the keyword list. This eliminates the need for the user typing the entire word.

Design Limitations

Having described the manner in which the system has been designed, the following paragraphs will discuss limitations that the current Reviewer's Assistant system contains.

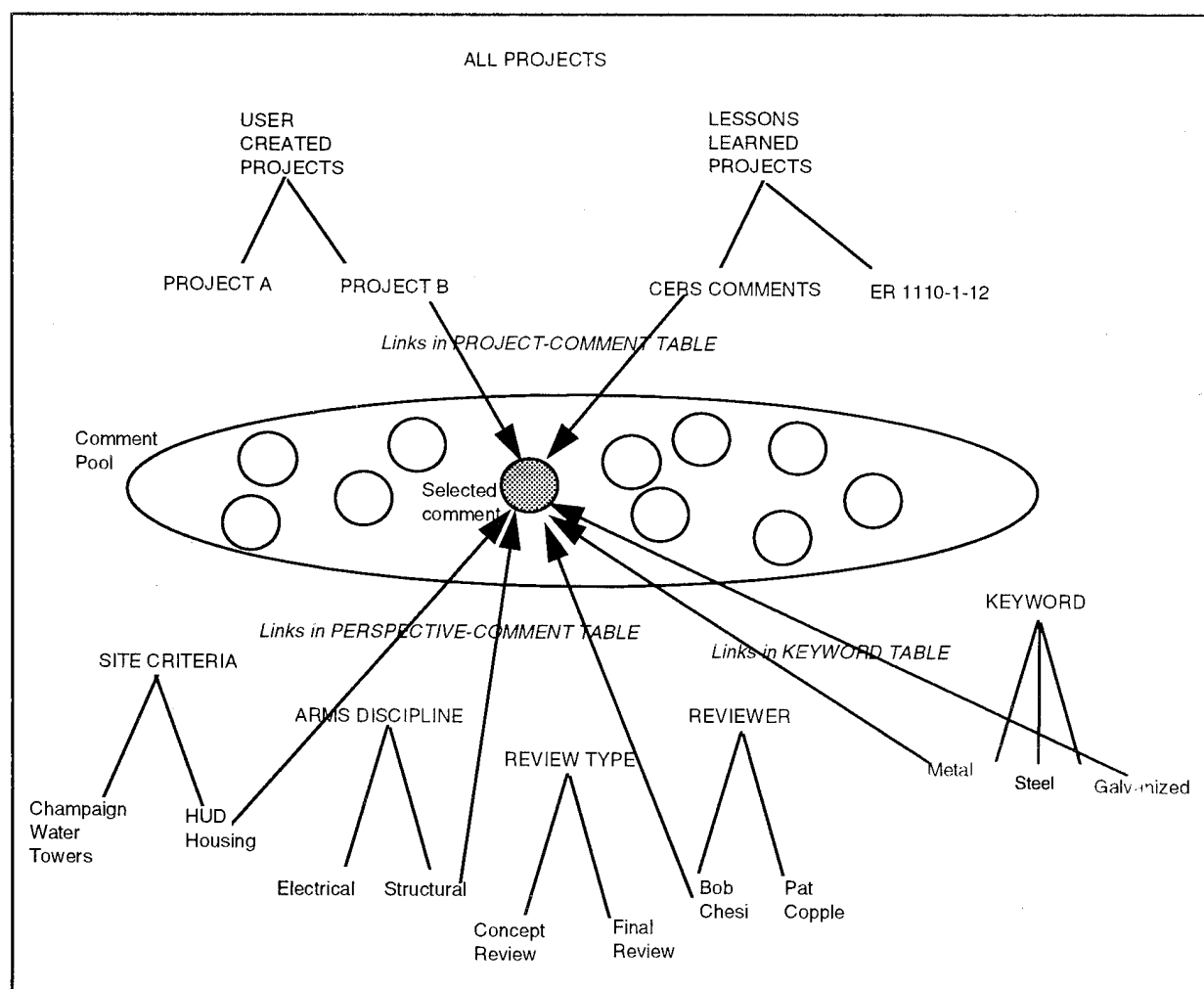


Figure 16. Perspective-comment link schematic.

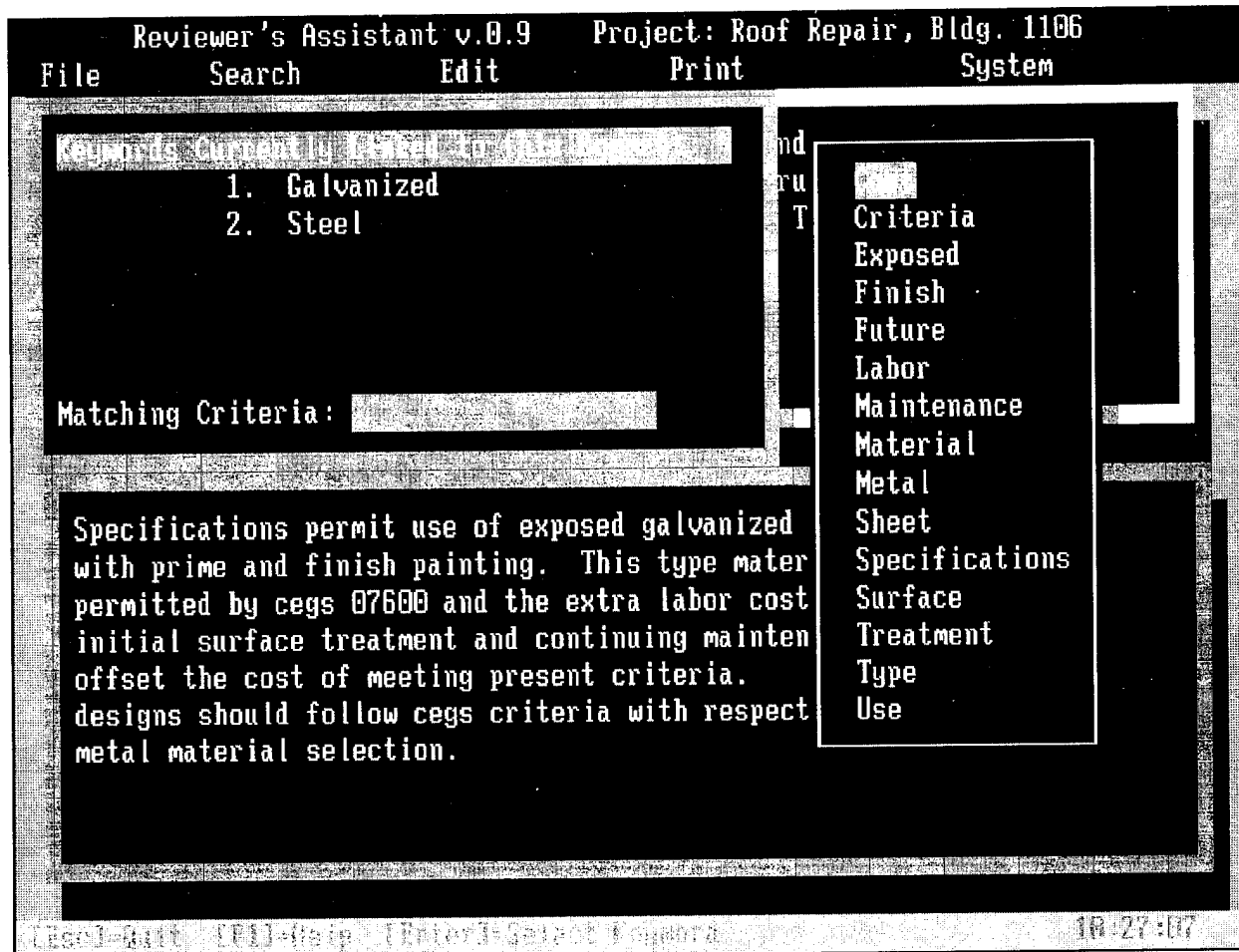


Figure 17. Linking keywords to a comment.

Feature-Value Combinations

The first limitation on the system involves the feature-value combinations. The feature-value combination is a key part of the Reviewer's Assistant. However, the user must be familiar with the CSI Specification Sections format in order to know which feature-value combinations to use in a search or when editing or creating a comment.

While most reviewers are so familiar with specifications that the specification numbers are used rather than the actual name, junior reviewers may have to search on more than one criterion, disregarding unrelated comments found in the search. All experienced reviewers use the specification sections, so the compromise was reached to use the name of the specification section as the basis for classifying review comments.

The flexibility of the Reviewer's Assistant is such that the feature-value combinations may be changed to reflect the needs of any individual user or office. The only restriction

on this flexibility is that some method of standardizing the feature-value classification scheme is necessary to ensure successful use of the system.

If a comment is entered with no corresponding feature and value, the program will only be found by searching on the reviewer. It will no longer exist in the FCMNTS table and, therefore, the comment will not be found on any specification section search of comments. This is a problem because if the user forgets to "tag" the comment with a feature-value combination, the comment is difficult to be accessed and used by others searching for comments based on specification section.

Though the perspectives provide another important means of classifying and searching for comments, other methods may be very useful. For example, instead of representing their thoughts in terms of categories or key words, reviewers may find that some design issues may best be illustrated through some means of graphical representation.

Limited Searching Strategies

A second limitation on the use of the current issue of the Reviewer's Assistant is that users must learn the idea of searching a database in order to use the program to its full potential. Providing general computer training is often sufficient to allow most users to successfully use the search routines. The search options offered in the current issue of the Reviewer's Assistant are considered a limitation in that there may be opportunities to improve upon these options. The following paragraphs describe these searching strategies,* and discuss some of the opportunities for future improvement.

The *Specification Section Search* allows the user to find past comments based on the selection of different paragraphs under each specification section that relate to that portion of the plans and specifications being reviewed.

The *ARMS Discipline Search* allows the user to find comments that have been directed at different designer or consultant disciplines. It is important to note that the ARMS discipline indicates who a review comment is to be directed to and not the discipline of the reviewer who created the comment. Future versions of Reviewer's Assistant may also allow names of A/E's and consultants to be entered under ARMS discipline.

The *Reviewer Search* enables the user to conduct a search according to the specific names of reviewers. This type of search may be conducted to find comments that have been used

* For a more detailed explanation of the search capabilities of the Reviewer's Assistant, please refer to the User's Manual (East, Lustig, and Roessler, September 1994).

by specific reviewers on past projects. Additionally, the user may use the reviewer search to find comments made by a reviewer with specific expertise.

The *Site Criteria Search* permits the user to find customer or geographic specific comments. Since many customers have preferences on items that may require change orders if not included in the original design, checking customer-specific criteria is important for any review. Similarly, geographic locations may have particular requirements that may be found through this search.

The *Keyword Search* allows the user to search for comments according to the most important words contained in the comments. This feature was added to the Reviewer's Assistant after a number of proponents expressed the desire for the capability to perform a more targeted search than those already listed.

The search capability is a very important part of the Reviewer's Assistant. This search element allows the user to specify the criteria to be used in a database review. Specifications and other criteria are tagged and then the program searches the database for comments that meet the criteria. Searches may be conducted to find comments matching combinations of search criteria. To explain combination searching, the following two sections are provided.

Search by single criterion. If the user searches with a single criterion selected, then all past comments that include the selected criteria will be copied to the current project. For example, if a search were conducted based on several different specification paragraphs, then comments matching any of these specification paragraphs would be copied to the new project. Similarly, if the search was based only on Reviewer and several names were selected, any comments matching any one of the names would be copied to the new project.

Search by multiple criteria. If a search is conducted based on multiple search criteria, the search becomes more complex. There are two options available for searching when multiple criteria are selected. The first option is a several stage search for any comments matching any of the criteria selected. This search occurs if the user chooses to conduct the search after identifying each search criteria. For example, if specification sections and reviewer were picked and the user searched after identifying the specification section, then searched again after selecting reviewers; the resulting search would be the same as if two separate searches have been conducted.

The second type of multiple criteria search combines the selections from different search criteria and finds those comments matching all of the criteria chosen. This type of search is, therefore, much more selective than the previously described search methods.

The second type of multiple criteria search occurs when searching takes place after the values of two or more criteria have been selected. For example, if a specification paragraph has been selected, and the reviewer does not elect to search, the reviewer then selects a reviewer name; the database will be searched to find only those comments that match both the specification section and the name of the reviewer selected.

The combination of different criteria will be extremely beneficial after users have created several projects. Users can then conduct searches such as: "find all comments I have made on flashing and sheet metal in the past" or "find all comments that John Doe has made that were sent to the mechanical consultant on past projects."

Search speed depends on the speed of the individual computer and the number of projects being searched. For AT-compatible (80286) computers, simultaneous searching on many criteria may cause delays. Also, searches on a computer using a 286 processor may take a few minutes.

Review Types

Comments entered into the program may be linked to a review type. In the current issue of the program, the review types are 35% Concept Review and 90% Final Review. Other review types may be added as needed.

The final restriction on the design of the system is the fact that the program only accounts for a single classification of review type for a project. The program does not allow for different "stages" of design completion within a project.

For example, a project may undergo a 90 percent design review using the Reviewer's Assistant. Depending on the circumstances of the project, not all of the design packages may be at or near 90 percent completion. The Architecture and Civil designs may be at 90 percent, while the Electrical may be at only 30 percent. Additionally, the security system may be government furnished, and only at the concept design stage.

This is a significant limitation on the design of the Reviewer's Assistant. If a comment addressing the Electrical design is entered in the 90 percent review, it will be classified as such in the database of the program, even though it may be only 30 percent complete. This may result in confusion when the comment is used on a future project. It is not clear what issues must be addressed to eliminate this limitation on the system.

Fixed Keyword Listing

In the current version of the Reviewer's Assistant, the keyword list may not be added to or edited. A method for allowing users to add their own keywords to the list is currently being researched. A significant limitation on this possible option is the fact that the keyword list is also used in the spell checker. Allowing users to edit the spellchecker list would present some problems.

Chapter Summary

This chapter has described the data structure of the Reviewer's Assistant. The data structure was designed with three goals in mind. The first goal was for the data to provide sufficient linking information to the design review comment to accurately represent the meaning of the comment and make it accessible on future searches. The next goal of the Reviewer's Assistant database was to create a flexible data structure that would allow each user or group of users to customize their system to meet the specific needs of their design review processes. Finally, the Reviewer's Assistant data was created to fully support ARMS. Comments may be linked to all data which is required for input into ARMS.

This chapter also discussed some of the limitations on the current issue of the Reviewer's Assistant. The feature-value combination scheme, and searching strategies in general, were discussed as a restriction on the use of the program by personnel without basic understanding of computer systems.

4 Proposed Reviewer's Assistant Modules

While the Reviewer's Assistant meets the immediate needs of providing a lessons-learned capturing program to assist in creating high quality, ARMS-compatible design review comments, discussions with program testers have shown several possible alternatives for the future capabilities of the Reviewer's Assistant. As the system is tested, the validity of each of the ideas discussed below will be tested and the most widely needed capabilities should be selected for further development.

This chapter is organized to allow the reader to find information on future project directions quickly and to the level of detail desired. Four possible future directions for the Reviewer's Assistant system are discussed along with exploratory work accomplished to define the scope of the four options. The four sections also provide an approach to implementation allowing the proposed future modules to be implemented in a practical and effective way.

While the discussion of these ideas is contained in specific sections, the modules may be combined to form a range of capabilities. The purpose of this chapter is to introduce possible capabilities of the Reviewer's Assistant and allow readers to offer feedback on these proposed ideas and identify the proposals or parts of proposals that could be combined to achieve a greater end product.

A Model-Based Reviewer's Assistant

Introduction

While an experienced design reviewer may know exactly which specification section^{*} relates to a specific design review, there may be additional information related to the design review comment that should be considered. This information may include military specifications, guide specifications, engineering and construction bulletins, submittals, and other data. The current version of the Reviewer's Assistant does not have links to this information. The first portion of the proposed model-based

^{*} For ease of discussion, the system's feature-value pairs and perspectives will be discussed in terms of their specific application to the Reviewer's Assistant system. The procedure described in this section is directly transferable to other domains.

Reviewer's Assistant would add the capability to retrieve additional related information, in both text and graphic form.

The second capability offered by the proposed model-based Reviewer's Assistant is the use of the system as a training tool for reviewers who are conducting a review in an area with which they are not familiar. For example, a less experienced reviewer may have difficulty finding a usable set of comments. This difficulty may result in the user having to manually review a large set of comments or giving up after not finding the set of comments that were expected. This possible enhancement of the Reviewer's Assistant would assist a reviewer not experienced in a particular area of the design to quickly find relevant background or reference material.

The model-based Reviewer's Assistant effort would begin by evaluating the applicability of the Microsoft Windows programming environment. Windows would be the most efficient user interface platform to integrate the variety of information sources needed to field a robust system. Windows also provides low-level software features such as memory management and error trapping that currently have to be accomplished by system programmers. Other programming features, such as the use of Windows graphics and word processors, would also be incorporated.

To provide the capabilities discussed above, the model-based Reviewer's Assistant would require two key components. The first component would create links between the contents of various documents to allow users to find textual and graphic information linked to a specific topic. The second component would allow the user to query the system to determine what types of issues should be addressed for specific building components.

In anticipation of the need to allow users to query the system on areas with which they are unfamiliar, the developers of the Reviewer's Assistant have created a prototype model-based system containing just one topic: low-slope or "flat" roofing systems. This prototype was developed in the Microsoft Access program. A description of the system and an example of the use of the data is provided in this chapter.

The model that has been developed is not intended to be an overall design review model. While there may not be a clear distinction between design reviews and BCO reviews, the proposed model, as much as possible, is limited to BCO issues. For example, thickness of insulation, fire rating, or wind uplift resistance rating are not considered; no analytical capabilities are implied to validate the design. The model described below helps to assess the BCO issues in the design, assuming that the decisions are valid.

The model consists of four parts: (1) identification of components, (2) identification of components' functions, (3) query of the design under review, and (4) commentary.

Part 1: Components

To build a model of any system, one must first identify the parts of that system. In the proposed model for BCO reviews, a classification of components and groups of components is created. Rather than an exact breakdown that may be fully supportable by every possible set of reference materials or scientific standards, the breakdown uses that combination of components on a project that are "natural" to a set of experienced quality assurance personnel. The following paragraphs explain the data needed to describe components in the proposed model.

The first piece of information needed to describe a building component is "Made Of" data. This data provides a list of possible materials of which the components are made. One of the possible materials is always "Any," which indicates that some components have characteristics that are present regardless of the material(s) of which they have been constructed.

A group of components or a complex component will be made not of a single material but of other, simpler components. For such a component, entries in the "Made Of" list would be other components rather than (or in addition to) materials. Hierarchies of components may then be developed to provide different levels of detail for different users.

The second information needed, "Described By," gives the specification classification that describes the component in the construction documents. CEGS are referenced where they exist. Where no CEGS is published for a specific item, the CSI classification is given.

"Described By" data could also include pictures of the installed items, or any other type of graphical information. The importance of graphics and pictures cannot be overstated. Future generations of the Reviewer's Assistant must have graphics, because drawings of how to build things are the basis of all engineering work.

The third item, "Related To," indicates other building components that have some bearing on the component's composition or performance. These are also identified by specification classification. CEGS are referenced where they exist. Where no CEGS is published for a specific item, the CSI classification is given.

Part 2: Function

The function describes why a component is essential to a building system, and how the parts of a system work together to create building systems that can stand the test of time.

For a given component, functions are given for "Made Of: Any," for functions common to all instances of the component, and for "Made Of: *Specific type*" for functions related to a specific material. The functions shown in the example show only the first type. By using the second type, reviewers could identify problems with any subcomponent that assists in the fulfillment of a function, and create a hierarchy of functions related to BCO problems to show how high-level building requirements are translated into combinations of other functions. (This hierarchy of functions was not compiled for the prototype developed in this study).

Part 3: Query

For each function, one or more checklist items, or queries, are provided. The queries assist the reviewer to assess the component's design and its prospective performance related to BCO issues. For this report, queries were developed from various sources of roofing construction information.

In addition to queries directly supporting the function of individual components, queries may also depend on combinations of related components. This type of multiple criteria query frequently occurs where differences in materials or interfaces between different building systems could cause BCO problems.

The reviewer may use these queries to identify if a potential problem condition exists. If that problem condition exists, then the final part of the component description is used.

Part 4: Commentary

If the user indicates, by answering the query, that a problem condition may exist, then the commentary section of a component description creates a comment to be sent to the ARMS system through the Reviewer's Assistant program.

While the commentary is listed as the last part of the component description, the commentary information is actually the most important. The commentary (BCO review comments) forms the basis for any review, and represents the failure modes of building components.

Sample Model

To illustrate the breakdown of a building system into the four parts described above, a model of a low-slope ("flat") roof is presented below. As discussed, a prototype model-based system has been developed using this data.

Identification of low-slope roof components. For simplicity, only the data for the component "Insulation" is given in this report.* The "Made Of" and "Described By" data for the insulation component is given in Figure 18.

Identification of components' functions. Functions have been defined for each component represented in the model. These functions were derived primarily from the CSI table of performance-specifying attributes, and adjusted according to the availability of information to support them. It is acknowledged that no single list of "Function" is infallible, and any number of variations might be composed. Insulation functions are listed in Figure 19.

Query and Comment

Selected queries and comments are provided for two components as examples of the model's contents. The "Insulation" content refers largely to constructibility characteristics of insulation as a material.

As an example of using Query and Commentary in the prototype system, imagine that a new project, "Roof Repair Building 1106," is to be reviewed. The reviewer decides to check how well the insulation will function given the plans and specifications that are provided on a project to renovate a roof. The design calls for a low-slope roof using polyisocyanurate roof insulation board. The insulation will be placed over a cast-in-place concrete deck and covered with a built-up roofing membrane. To assist the user in

following the steps to be outlined in this example, a flow is provided in Figure 20.

First, "Insulation" is selected from a graphical representation of the roofing system as the component to be checked. The characteristics of this component are also shown.

Insulation may be "Made Of" the following:
Cellular glass board
Composite board
Glass fiber board
Perlite board
Polyisocyanurate foam board
Polyurethane foam board
Insulation (any type) is "Described By":
CEGS 07220, Roof and Deck Insulation.

Figure 18. Data for the component "Insulation."

* For complete documentation of this model, please contact the authors at 800-USA-CERL.

Allow fastening or adhesion to the deck
 Resist physical damage from impact, crushing
 Maintain fire safety integrity of the roof assembly
 Resist thermal transmission
 Resist moisture damage
 Maintain dimensional stability
 Maintain compatibility with other components

Figure 19. Insulation functions.

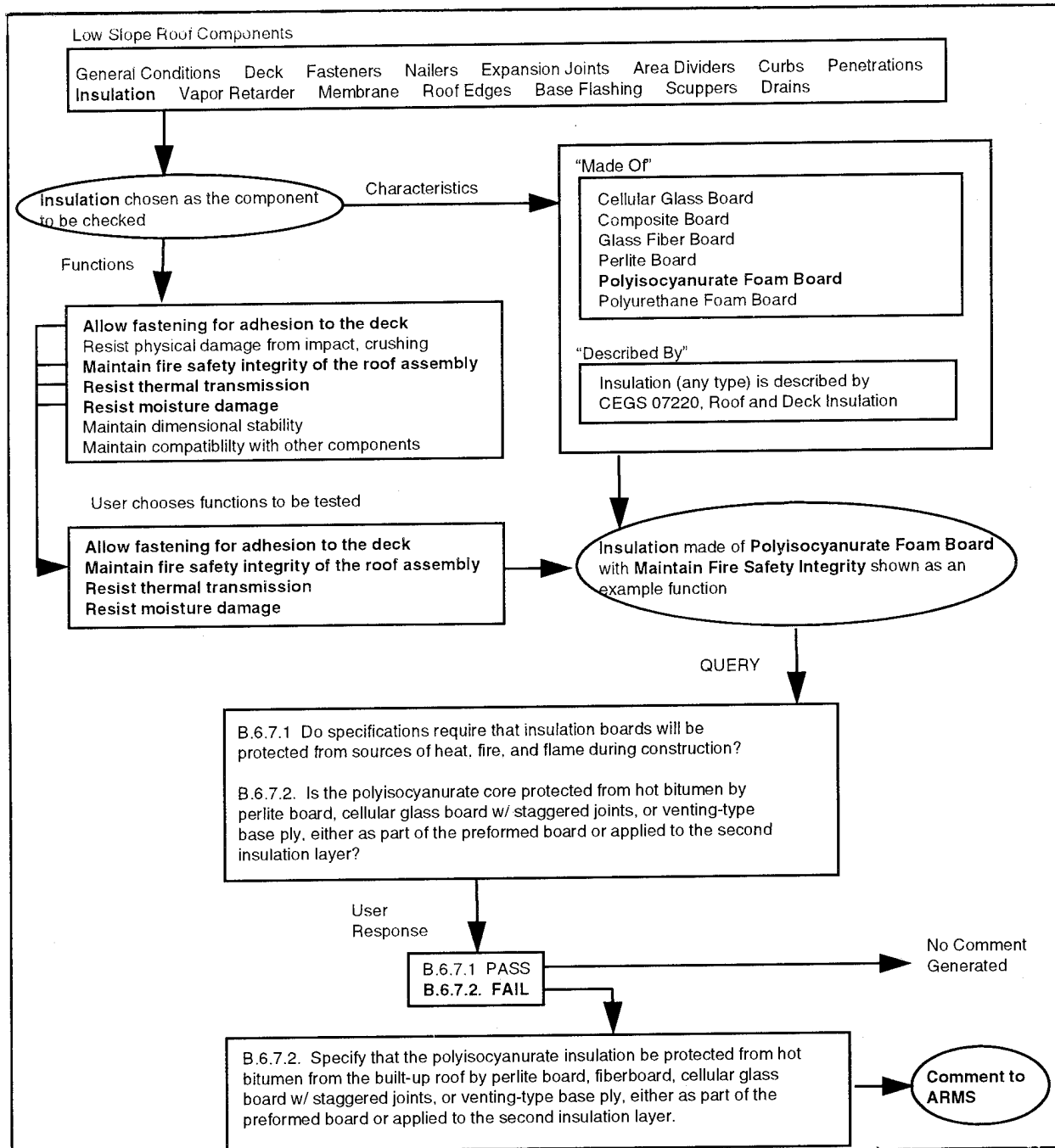


Figure 20. Example application of a model-based Reviewer's Assistant.

Based on the design, the reviewer decides to check how well the insulation board will work on the project. After being presented with the list of functions to check for, as shown in the figure, the user selects the following four functions to review: (1) allow adhesion/attachment, (2) resist thermal transmission, (3) resist moisture damage, and (4) maintain fire safety integrity. The process is shown in the figure with "Maintain fire safety integrity" given as a representative example of a function.

Once the functions to be reviewed are selected, the system will provide the queries, a list of issues to be checked. The first set of items to be checked cover any type of roof insulation material (Made of: Any). The remaining items refer to the specific type of material being installed on the current project (Made of: Specific type). The user may also want to access the related CEGS.

Based on the user response to the queries (pass, fail, or not applicable), the commentary will be generated for that particular review. The queries and commentary for the component "Polyisocyanurate insulation" and for the four functions listed above are as follows:

COMPONENT:	<u>B. ROOF INSULATION.</u>	
MADE OF:	<u>1. ANY MATERIAL TYPE.</u>	
DESCRIBED BY:	<u>CEGS 07220, Roof Insulation.</u>	
RELATED TO:	CEGS 03300,	Concrete for Building Construction.
	CEGS 03510,	Roof Decking, Cast in Place Low Density Concrete.
	CEGS 03511,	Gypsum Plank Decking.
	CSI 03530,	Cementitious Wood Fiber Systems.
	CEGS 03550,	Precast/Prestressed Concrete Floor and Roof Units.
	CEGS 05300,	Steel Decking.
	CEGS 06100,	Rough Carpentry.
	CSI 07190,	Vapor Retarders.
	CEGS 07250,	Spray Applied Fire Proofing.
	CSI 09500,	Acoustical Treatment, Acoustical Insulation.
	CEGS 07510,	Built-Up Roofing.
	CEGS 07530,	Elastomeric Roofing (EPDM).
	CEGS 07535,	Modified Bitumen Roofing.
	CEGS 07555,	Polyvinyl Chloride Roofing (PVC).
	CSI 07720,	Roof Accessories.
	CEGS 09250,	Gypsum Wallboard.

QUERY:

MADE OF: ANY

FUNCTION: 2. Allow adhesion/attachment.

- B.1.2.1. Will installation conditions permit hot bitumen be applied within 25F above or below the bitumen's EVT ?
- B.1.2.2. Will the specified fastening pattern be readily recognizable to inspectors, i.e., number of fasteners per board or spacing of 12 in. or 24 in. increments ?
- B.1.2.3. Where roof slope is greater than 1/2 in. per foot, are nailers provided for insulation support and the backnailing of the membrane ?

If insulation is applied to a cast in place concrete deck:

- B.1.2.12. Will the concrete deck be sufficiently hydrated and the surface thoroughly dry at the time of installation; is a Dryness Test in the insulation specifications ?
- B.1.2.13. Will deck be primed with an asphalt primer prior to installation of insulation ?
- B.1.2.14. Is a base sheet specified to be solid mopped with hot asphalt at rate of 25 lbs/square ?
- B.1.2.15. Is insulation adhesion specified as hot asphalt applied at a rate of 25 lbs/square for first layer and 30 lbs/square for second layer ?

FUNCTION: 4. Resist Moisture Damage.

- B.1.4.1. Have moisture conditions during both construction (i.e., plaster work, concrete hydration) and occupancy been identified to verify whether a vapor retarder is or is not required?
- B.1.4.2. If required, is a vapor retarder clearly indicated in the construction documents ?

- B.1.4.3. Has dewpoint location under design conditions been verified to be on the exterior side of the vapor retarder ?
- B.1.4.4. If a vapor retarder is required, will it extend over roof edges and walls and returned over the vapor retarder surface prior to installation of the roof insulation ?
- B.1.4.5. If a vapor retarder is required, will it extend over openings and terminations other than roof edges and walls, and returned over the top of the insulation ?

MADE OF: POLYISOCYANURATE INSULATION BOARD.

FUNCTION: 2. Allow adhesion/attachment.

- B.6.2.1. Will disks of minimum 1 in. diameter be used with mechanical fasteners to ensure fastener retention in insulation and prevent crushing ?
- B.6.2.2. If insulation boards are adhered with hot bitumen or bitumen adhesive, will there be a mechanically fastened base sheet or vapor retarder ?
- B.6.2.3. If insulation is applied directly to a steel deck (not mechanically fastened), is application by hot asphalt or asphalt adhesive, strip mopped 6 in. o.c., at rate of 12-25 lbs/square ?
- B.6.2.4. If insulation is applied to a non-nailable deck, is application by hot bitumen or bitumen adhesive ?

FUNCTION: 5. Resist thermal transmission.

- B.6.5.1. Will the polyisocyanurate insulation core material be aged prior to arrival at site ?
- B.6.5.2. Does the Design Analysis verify that the aged thermal resistance value has been used in calculating insulation requirements ?

FUNCTION: 7. Maintain fire safety integrity.

- B.6.7.1. Do specifications require that insulation boards will be protected from sources of heat, fire, and flame during construction ?

- B.6.7.2. Is the polyisocyanurate core protected from hot bitumen by perlite board, fiberboard, cellular glass board, w/ staggered joints, or venting-type base ply, either as part of the preformed board or applied to the second insulation layer ?

RESPONSE: *(The reviewer makes the following responses.)*

B.1.2.1. PASS
B.1.2.2. PASS
B.1.2.3. FAIL

B.1.2.12. FAIL
B.1.2.13. PASS
B.1.2.14. FAIL
B.1.2.15. FAIL

B.1.4.1. FAIL
B.1.4.2. FAIL
B.1.4.3. FAIL
B.1.4.4. FAIL
B.1.4.5. FAIL

B.6.2.1. NA
B.6.2.2. NA
B.6.2.3. NA
B.6.2.4. PASS

B.6.5.1. FAIL
B.6.5.2. FAIL

B.6.7.1. PASS
B.6.7.2. FAIL

COMMENTARY: *(Forwarded to reviewer's report)*

- B.1.2.3. The roof slope is greater than 1/2 in. per foot. Install nailers perpendicular to the slope, spaced at approximately 30 ft for insulation support and the backnailing of the membrane. Nailers must be of same thickness as the insulation.

- B.1.2.12. Specify a Dryness Test be performed on all areas of the deck in the insulation specifications.
- B.1.2.14. Provide a base sheet to be solid mopped with hot asphalt at rate of 25 lbs/square.
- B.1.2.15. Adhere insulation boards with hot asphalt applied at a rate of 25 lbs/square for first layer and 30 lbs/square for the second layer.
- B.6.5.1. Specify that the polyisocyanurate insulation core material be aged prior to arrival at site.
- B.6.5.2. Review the Design Analysis to ensure the K and R values for aged polyisocyanurate insulation are consistent with the roof's required thermal performance.
- B.1.4.1. If construction operations include placing concrete, especially a concrete roof deck, installation of a vapor retarder is highly recommended.
- B.1.4.2. If required, ensure that the vapor retarder is indicated in the construction documents and that locations and boundaries of the vapor retarder clearly defined.
- B.1.4.3. Review the Design Analysis to verify the location of the dew point under construction and design Relative Humidity conditions. Verify the location of the vapor retarder to be on the interior of the dew point.
- B.1.4.4. Extend the vapor retarder to seal against a vertical air barrier, and to lap over the vapor retarder at roof edges.
- B.1.4.5. Extend the vapor retarder over openings and terminations other than roof edges and walls, and returned over the top of the insulation.
- B.6.7.2. Specify that the polyisocyanurate insulation be protected from hot bitumen from the built-up roof by perlite board, fiberboard, cellular glass board with staggered joints, or venting-type base ply, either as part of the preformed board or applied to the second insulation layer.

Summary

This section, **A Model-Based Reviewer's Assistant**, has described a structure upon which a model of the interaction of building systems for design reviews may be constructed. The example above gives only a hint of the capability that such a model could provide. If developed, the model would be able to:

- Provide project-specific reviews based on the contents of each design
- Provide reviewers with a tool to assist them in looking at groups of building components that impact design quality
- Allow users to access reference sources related to the review being conducted
- Provide users with standard details to compare to those on the design
- Provide novice users with a tool to learn about building systems and components.

Using Limited Natural Language

The flexibility to access data in different ways allows users with varying levels of computer experience and different problem-solving approaches to successfully use a software system. One of the access mechanisms that has been successfully employed in the past is natural language processing. While having the computer respond to freely formed questions is not possible with today's technology, having users access a specialized set of data using a limited vocabulary is within the scope of current technology. Using a limited domain natural language interface, words or phrases may be substituted for menu selections or data selection.

Navigating in the Reviewer's Assistant system has been streamlined as much as possible based on beta-testing, but it still requires the user to have some knowledge about how the program is structured. Adding the Limited Natural Language module described below would provide limited-vocabulary language processing to assist in:

- Providing suggested codings for comments that the user adds
- Executing and operating the program using a verbal or pen interface.

Default Comment Categorization

The first part of this possible system enhancement is the development of a module to help users classify comments that are new or obtained from other sources (such as ARMS) as they are loaded into the Reviewer's Assistant system. A grammar to connect the keywords (from the first part of this module) will be developed to create a limited-domain, natural language pre-processor for review comments. It is expected

that this pre-processor could be useful not only for future use of the Reviewer's Assistant but also to assist in transferring the volume of ARMS comments that are currently in text file format into a database format.

The motivation for this portion of the limited natural language interface is to reduce the time required to categorize comments in the comment edit screen. To be useful for a future project, a comment must be categorized according to the specification section, site criteria, reviewer, review type, and other items. With a comment categorization capability, the Reviewer's Assistant system would provide default categorization information based on the comments; the user would only have to change these defaults as necessary, rather than entering all the information.

There are several possible approaches to implementing the default comment categorization capability. In the most basic form, the system would provide a default specification section only. A routine would take each word in a comment and check the word against the list of keywords. If a match between a single keyword and a word in the comment is found, then a default value for specification sections would be provided and the user would be asked to confirm or change the selection.

A more advanced case would be to provide default values for specification section(s) *and* perspectives, because when editing comments, the user might wish to identify more than simply the specification sections associated with the comment. Other items, such as ARMS discipline, would also have to be checked. To link perspectives and keywords, additional database tables may be needed.

To allow a system manager or administrator to link the keywords to the perspectives as well as the specification sections, system-level menu selections would also be needed. Developing the initial contents of the linking tables would require significant effort from both USACERL personnel and subject matter experts at a Corps of Engineers District.

The previous two descriptions of natural language analysis of comments focused on taking each word of the comment and checking against each word in the keyword list. While this approach would provide some initial relief from selecting database indices, a more complex matching strategy would ultimately be required. A grammar to cover searching of more than one word would connect the keywords to create a limited-domain natural language pre-processor for review comments. Such a pre-processor could be useful not only for future use of the Reviewer's Assistant but also for transferring the volume of ARMS comments currently in text file format into a database format.

Verbal/Pen Interface

As already discussed in this report, the Reviewer's Assistant system has been developed with the needs of review personnel in mind. A problem the current version of the Reviewer's Assistant will not eliminate is the limited resources available in field offices. For example, if an office has no computer located where the plans and specifications are reviewed, the reviewer has to write review comments on a scratch pad, then retype them into the Reviewer's Assistant system. The developers feel it is important to allow for remote use of the Reviewer's Assistant within or away from the office by providing a more portable input device than a desk computer.

The second portion of the Limited Natural Language module would allow the user to enter words or phrases to operate the computer program through the use of either an "electronic clipboard," or a voice recognition system. Either of these systems should be programmed in such a way as to allow users to avoid menus and other programmer-created organizational structures and move more freely within the system.

The electronic clipboard is a means of entering data into the computer by writing it directly, using a special pen. This would mean that the Reviewer's Assistant could be operated by simply touching a small computer screen. Additional possibilities for this "pen-based" use of the Reviewer's Assistant include the ability to directly enter review comments on the clipboard and to scan a portion of the design drawings to use the drawing itself in the design comment. Voice recognition technology could be used in the same way as the clipboard. The program could be run, and review comments entered, by simply speaking into a microphone.

Ultimately, both the pen-based and voice-based technologies could be used in conjunction with the Reviewer's Assistant. The software may eventually be packaged with both a headset and microphone for voice recognition and a clipboard set with scanning capabilities. Included in this package would be a "design checklist" provided by an external organization (ASCE, CII, etc.). This "Reviewer's Assistant Kit" would provide an extremely versatile tool for design review personnel.

Simple Machine Learning Applied to the Reviewer's Assistant

In systems dealing with an ever-increasing body of expertise, the idea of assessing knowledge by quality, or usefulness, is essential. The databases of Reviewer's Assistant users will grow rapidly as the system is used. During one fiscal year, several hundred projects may be reviewed in a single District Office. As the number of comments in the

system increases, database searches will yield an increasing number of comments of varying degrees of usefulness to the reviewer. Without some notion of quality to order the information or to constrain the search, the reviewer is forced to examine all resulting comments to find the comments that apply to the project.

To maintain a manageable database, some method of abstracting repetitive comments must be developed. To meet this objective, a prototype Lessons Learned Generator has been developed in conjunction with the Reviewer's Assistant system (Fu and East 1990).

An important function of the Lessons Learned Generator is to classify design review comments according to their "quality." Quality in design review comments can be measured by three attributes: usefulness, generality, and content stability. *Usefulness* refers to the content of the comment; it measures how well a problem and its solution are described, and the relevance of the problem/solution to the design review process. *Generality* refers to the applicability of the comment across projects. Many design review comments are specific to a single or a small set of projects. Their applicability to a wide range of projects is limited. However, the comment cannot be so general as to lack sufficient context to describe what must be done.

Content stability is also a concern. As comments are copied from project to project, reviewers may alter the contents of the comment, thus causing *content shift*, or significant change in the "idea" represented in the review comment. Comments experiencing severe content shift cannot be abstracted, since it is unclear what meaning of the comment has become.

Some examples of low quality comments are:

"The design team shall consult with the Base Civil Engineering Office to review the installation's program of architectural compatibility. The design team shall be sensitive to the cultural, architectural, and environmental influences that affect the installation and the particular site proposed for the project."

"The visual design of the project should be in harmony with its surrounding."

"Secure rooms and vaults have bars in ducts."

The Lessons Learned Generator finds and abstracts high quality comments using a two-phase process. The first phase searches for comments that are *useful* by observing the patterns of comment reuse by reviewers. There is an assumption made that if a comment

is reused, it is useful. This assumption is made based on the observation of design review practice: paper sets of repetitive deficiency lists are frequently used and distributed by the Corps of Engineers at all levels of the organization.

An example of a high-quality comment is: "The specification indicates copper roof pan lengths to be approximately 45 ft long. The Copper Development Association recommends 30 ft maximum pan lengths, especially in northern tier climates. Copper expands 1/8 in. per 10 ft for every 100 °F of temperature change. The 45-ft-long pans with expansion cleats are theoretically possible, but not practicable during installation."

In Phase I, the Lessons Learned Generator calculates a comment frequency threshold from the existing project databases. Comments whose frequency exceed this threshold are hypothesized as high quality comments.

The second phase involves a closer look at the comments to determine *content stability* and *generality*. The content of the comment is analyzed for commonalities, using the tag information linked to the various instances of the comment. If content shift has not occurred, the comment is abstracted to the Lessons Learned database. The Lessons Learned Generator has several heuristics to judge whether a comment has experienced content shift.

The Lessons Learned Generator Algorithm

To illustrate the algorithm, assume that there are five unique comments in the database. The two phases of the algorithm are described in this section.

Phase 1: Calculating a comment frequency threshold. In Step 1 of this phase, the algorithm creates a table of comment frequencies, with each entry in the table corresponding to the number of times a particular comment is used in the entire database. This results in the following pairing of comment numbers and frequencies:

Comment Number	1	2	3	4	5
Number of Instances	2	1	2	3	4

In Step 2, the algorithm calculates the expected comment frequency and averages the comment frequencies to obtain the comment frequency threshold. For the example, the comment frequency threshold value would be:

$$(1/5) * (2 + 1 + 2 + 5 + 3) = (1/5) * 13 = 2.6$$

Therefore, only comments four and five, comments whose frequencies exceed 2.6, would be considered for the subsequent steps.

Phase 2: Abstracting the selected comments. For each comment with a frequency greater than the threshold, the algorithm finds all instances of the comment and collects and analyzes the tag information for commonalities. The commonalities are called *condition attributes* for the comment. For the example, the three instances of comment number four have the feature-value combinations shown in Table 4.

The intersection of the feature-value combinations of the three instances is computed. In this case, only a single feature-value combination exists in all three instances: *Thermal and Moisture Protection/Waterproofing*. This particular feature-value combination becomes a condition attribute for comment number four. An identical operation is performed on the perspectives and keywords.

The keywords and feature-value combinations are the critical condition attributes in determining the content of a comment. All instances of a comment must have at least one keyword *and* at least one feature-value combination in common to be used by the Lessons Learned Generator. Otherwise, the comment has undergone content shift and is not abstractable.

An *abstracted comment* contains the comment text and the condition attributes found in the tag information analysis. Each abstracted comment is saved as a Lessons Learned project. All other instances of the comment in the database are deleted.

A Sample Run of the Lessons Learned Generator

To illustrate the behavior of the Lessons Learned Generator, a small test database was created consisting of five design reviews of roofing projects. For each project, searches obtained comments from previous projects, and new comments pertaining to the specific design were added.

Table 4. Feature-value combinations for Comment Four.

Instance	Feature/Value
1	<i>Thermal and Moisture Protection/Waterproofing</i> <i>Thermal and Moisture Protection/Water Repellents</i>
2	<i>Thermal and Moisture Protection/Waterproofing</i> <i>Doors and Windows/Metal Doors and Windows</i>
3	<i>Thermal and Moisture Protection/Waterproofing</i> <i>Thermal and Moisture Protection/Dampproofing</i>

Figure 21 shows the screen that the Lessons Learned Generator displays after the frequency threshold calculation phase. The comment frequencies have been tabulated and the frequency threshold computed.

After the abstraction process, the Lessons Learned Generator displays a comparison of the comments frequently used to those that exhibited content shift.

Problems and Future Research

The Reviewer's Assistant is still in the testing phase. As a result, databases of design reviews created over a period of time do not yet exist. As these databases become available, the developers will be better able to assess the performance of the Lessons Learned Generator. However, even the small test discussed in this paper demonstrates future areas of improvement and research.

One area for improvement is that of the abstraction heuristics, specifically for deciding on the condition attributes and determining content shift. The current algorithm assumes that when reviewers modify their comments, they also modify the tag

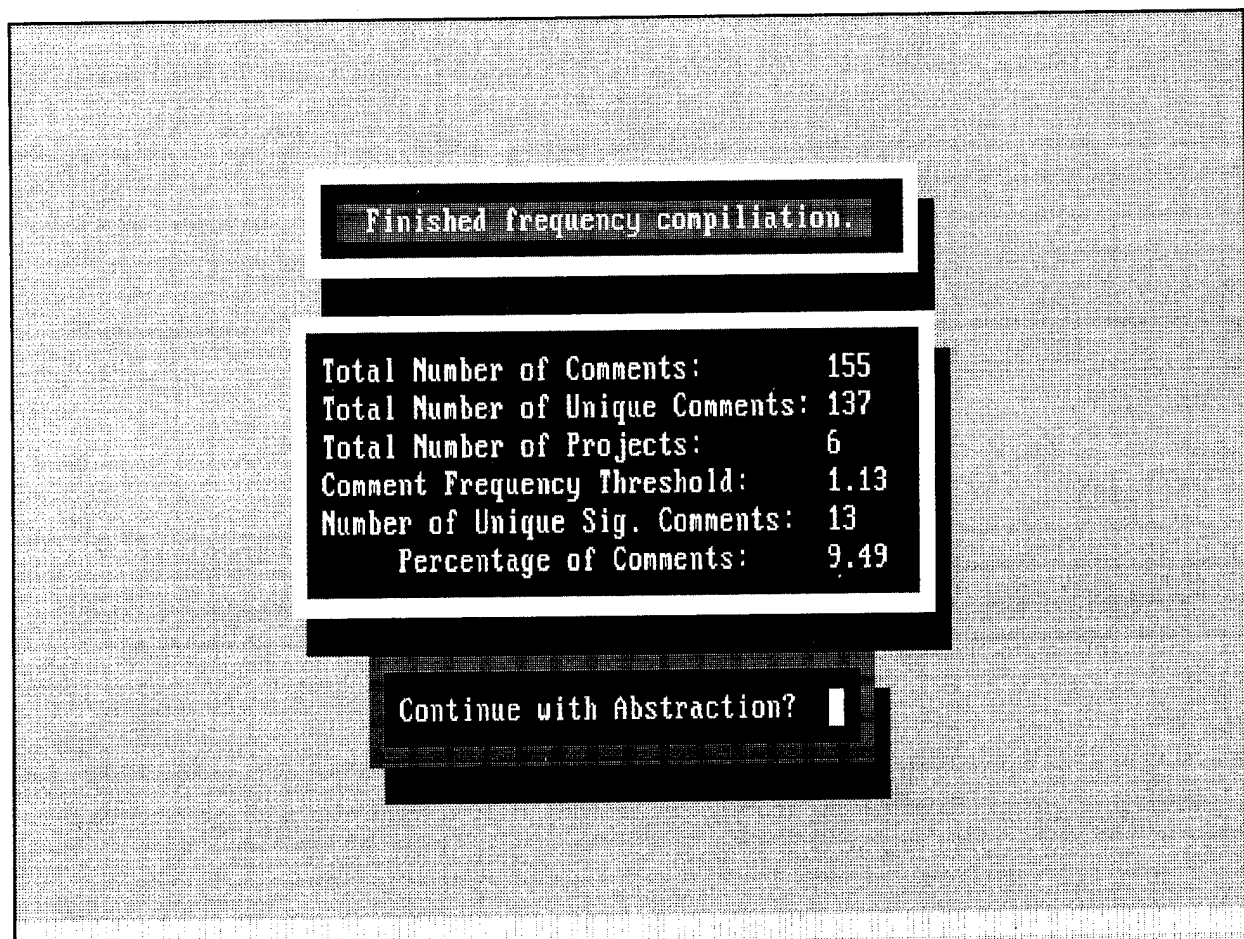


Figure 21. Frequency threshold calculation screen.

information linked to the comments. Because this is not always true, it would be useful for the system to force the user to examine the tag information when the algorithm detects content shift. A good detection measure would include analysis of the tag information that was changed, and perhaps an examination of the text of the comment itself. Another solution to the problem is to conduct a keyword analysis in addition to using the reviewer-linked tag information.

The current statistical method used for the frequency threshold calculation is relatively simple. Better tests for frequency significance from the fields of statistics and information theory should be evaluated. Since the algorithm's abstraction phase (Phase 2) is computationally more expensive than the first phase, a better measure of comment significance would reduce the number of comments considered in the second phase, and overall run time would decrease.

Conclusion

The Lessons Learned Generator works in the context of the Reviewer's Assistant system to abstract high quality comments from a large set of BCO or other design reviews. Quality is defined in terms of usefulness, generality/specificity, and content stability. A high quality comment is one which addresses an important problem and is clearly and concisely written. The algorithm used by the Generator relies on patterns of reviewer usage to determine the quality of comments.

As the Lessons Learned Generator is run on a growing database, the bank of Lessons Learned data will grow, allowing the database as a whole to remain manageable. This Lessons Learned data would give the user of the Reviewer's Assistant a very important means by which to search for and reuse comments. By searching the Lessons Learned database first, the reviewer has the opportunity to access comments with high probability of usefulness before dealing with a potentially large number of comments of widely varying quality resulting from a comment search. Lessons Learned projects may also serve as a checklist for design reviewers and as a learning tool for novice review personnel.

Imbedding the Reviewer's Assistant Into a CADD System

The best use of any design review comment would be to have the comment applied as a designer is documenting the design plans and specifications. One of the proposed enhancements to the Reviewer's Assistant is to integrate the design review comments contained in the Reviewer's Assistant with PC-based computer-aided design and drafting (CADD) systems. The four different levels of interaction that could be developed

are: (1) use of a linking table to associate CADD elements with specification sections, (2) evaluation of changes that occur to a design, (3) providing a set of possible options during the design, and (4) automated evaluation of some design features for potential design problems.

Associating CADD elements with specification sections. CADD system users have been working to develop standard sets of details and standards to describe various portions of a construction. Single-discipline task groups within the Corps of Engineers have been at the front of this effort. Agreement on these details and standards forms the basis for the first step in integrating the Reviewer's Assistant system with CADD systems.

Once the details and standards are connected to specification sections, review comments related to those specification sections may be accessed through a linking table. Creating a Reviewer's Assistant icon in the CADD system and using the linking table would allow the designer to have a window displaying the appropriate review comments. An alternative is to allow the CADD system to keep track of all details and standards used by the designer since the last review. The Reviewer's Assistant would then be able to provide the designer a list of items to be checked.

A prototype system to demonstrate the link between CADD systems and the Reviewer's Assistant would be started by selecting a relatively simple building system; built-up roofing, for example. The standards and details created by the single discipline task group related to built-up roofing would be gathered and categorized. A database table in a CADD system, containing indexes, descriptions, and information related to each standard and detail, would then be created. In addition to some general information, this table would contain the categories needed to support the linking routines, such as specification sections and paragraphs, sheet/detail/room numbers, and the related design discipline. With this information, the Reviewer's Assistant database could be accessed and the appropriate checklist items provided to the user.

Evaluating design changes. The second level of interaction between the Reviewer's Assistant and CADD systems that could be developed is a tool for the evaluation of changes to a design. In this module, as the designer makes a change to a design, a file of checklist items related to the change could be developed. At the designer's discretion, this checklist could be reviewed.

To implement the second level of interaction, substantial work needs to be developed to adequately represent a variety of building systems. There have been several demonstrations of systems that operate with standard designs. However, developing an intuitive user interface to allow the system to grow into a broad range of buildings and

systems is critical to widespread use of the system. Limited prototypes may be developed in twelve to eighteen months following the completion of the previous phase of the work.

Options. The third level of interaction would be to allow the Reviewer's Assistant to take a more active role in assisting the designer. This role could take a number of different forms in its user interface. The basic idea is that, as the designer wants to make a change to a given item, the Reviewer's Assistant would provide a list of acceptable alternatives. The conceptual enhancement to support the third level of interaction is that environmental and project-external considerations would be needed in order to evaluate the constraints placed on the design.

Automated evaluation. The final, and most complicated, of the four possible types of integration of the Reviewer's Assistant and CADD system would be the development of a design evaluation tool. This tool would operate very much like a powerful word processor package. There would be the equivalent of a "spell checker" that would identify possible alternatives for a given design item. There would also be a program to check the "syntax and grammar" of a design, or how the design options interact with one another. It is too early to determine how long it would take to complete this module of the program. However, this module is a natural progression in complexity from the previous three modules.

5 Conclusions

The objective of this project documented in this report was to identify methods to improve the efficiency of personnel conducting BCO reviews. This led to an in-depth study of computer programming paradigms to find a system that matched, as closely as possible, the process followed when personnel conduct BCO and other design reviews. As a result of the work described in this report, a system called the BCOE Advisor was developed, and after testing a generic design review tool, the Reviewer's Assistant was developed.

"Expert" system approaches were reviewed and found to be inappropriate due to the unique nature of construction projects to be reviewed. A case-based reasoning (CBR) approach was explored and found to be suitable for the requirements of the personnel conducting reviews. The initial implementation was programmed in the "C" programming language. The Reviewer's Assistant's data is stored within a database format, but the design and approach to the system was not a database approach.

The CBR paradigm implemented within the Reviewer's Assistant will solve a significant portion of the problems associated with performing design reviews. Essentially, CBR allows users to find and adapt past projects with characteristics that are similar to an existing situation. This combination of the computer's memory and the human's knowledge provides the best possible man-machine interaction available given the constraints under which the system was developed.

To use the program, the project engineer identifies the critical components of the project being reviewed. Using the Reviewer's Assistant, all comments associated with these criteria on past reviews may be found. Once the comments from past reviews have been brought into the new project, the user may adapt those comments to insure that they are correct for the specifics of the new project.

The Reviewer's Assistant data structure provides an effective, flexible way to store and retrieve review comments. To support data standardization throughout the Corps, the data format is fully compatible with ARMS. Design review comments may be downloaded from ARMS or uploaded to ARMS easily. Additionally, the initial Reviewer's Assistant database is populated with standard Corps of Engineer data from CERS and ER 1110-1-12. Other "lessons learned" can be easily distributed and loaded.

Use of the April 1994 edition of the Reviewer's Assistant system provides two key benefits to the design review process. First, because users from all levels of experience will be able to browse through and apply comments from past reviews, individual design reviews will be more complete. Second, in most cases design reviews can be completed more quickly.

Looking ahead to ways in which the Reviewer's Assistant might further improve the efficiency of construction personnel conducting design reviews, this report also describes possible future enhancements to the system, with the hope of generating user feedback about these ideas.

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Appendix A: Construction Evaluating Reporting System (CERS) Comment List

1. Miscellaneous fasteners such as wing nuts, tiedown system for roof top A/C unit, bolts, and fasteners for cap flashing are all noted to be rapidly deteriorating in the salt-spray-laden atmosphere. Specify materials which are relatively unaffected such as 316ss. Plain carbon steel, cadmium plated, and galvanized apparently will not last in this type of environment.
2. Kitchen equipment is government furnished. Facility is contractor designed. Equipment, while not unsuitable for the facility as designed, does not correctly fit the allotted space, leading to a high level of dissatisfaction on the part of the user. This dissatisfaction was demonstrated during inspection of the facility. On future projects using the single step procurement process, a waiver should be obtained to allow the kitchen equipment to be contractor furnished.
3. Building water main on some units is routed under the width of the building to the mechanical room. This is not desirable from a maintenance standpoint. Route water main to mechanical room outside the building line to facilitate maintenance and to provide more ready access.
4. Mechanical equipment is not to receive seismic bracing. Fan coil units and piping are suspended from the structure using threaded rod and "C" clamps. The site is in seismic zone 4.
5. Door pockets for overhead doors are constructed of concrete. This results in the contractor having to form and pour 2-in.-thick sections of reinforced concrete with less than acceptable results. Large voids were noted, which will be difficult to patch. Additionally, the concrete is not sufficiently impact resistant. A door pocket constructed of steel is a cheaper, more suitable material.
6. #3 reinforcing bars are being placed 36 in. on center in cells in all concrete masonry unit (CMU) walls. The site is in seismic zone zero. Normal design does not require vertical reinforcing. Bicycle storage facility also noted to have excessively large footings. Facility was noted to have been bid at 119 percent of programmed amount (p.a.) and rooms were removed to award the facility within the p.a. Vertical reinforcing should

reinforcing should not be included in seismic zone zero except at openings and control joints. It can be assumed that the design directly contributed to the downsizing of the facility. If the observation is rebutted, the rebuttal must include a design analysis to include calculations which will be forwarded for review.

7. The conduit for the underground primary electrical power supply is in a 4-in. polyvinyl chloride (PVC) pipe. Drawings call for concrete encasement only under roads and structures, and for direct-buried installation 30 in. under finish grade or grass. This is hazardous for any future excavation. All underground primary should be concrete-encased or in steel conduit.

8. Blast door was not available at the time the blast hardened wall in which it was to be installed was constructed. Wall was cast with provision for hinge anchorage on door blocked out. However, door manufacturer's literature states that door shall be cast in wall and that the door itself shall be cast in the closed position. This cannot be accomplished now. Blast doors are a specialty item and require long lead times for procurement. Doors are therefore often not available when walls are constructed, necessitating a blockout. Because of unique requirements for blast hardening, a detail should be included in the drawings. On this project, the manufacturer's recommendations should be obtained and followed.

9. The main corridor along the center of the building has a number of exposed panel boxes and exposed conduits along the wall. These items are subject to damage from vehicles traveling through the corridor. Relocate each item or build protective enclosure as appropriate.

10. Foundations for masonry walls consist of grade beams on pilecaps. The top of the grade beam is designed to be at the same elevation as the finished floor slab. The finished slab is steel trowel finished. The grade beam is floated. This does not provide an acceptable floor finish at door openings. Design grade beams so they stop below floor slab elevation. On strip footing, construction the concrete stem wall should be deleted and the first masonry course founded directly on the footing.

11. Contract drawings do not show hazardous classification of storage and tunnel. Ammunition storage facilities usually are classified in accordance with Article 500 of the National Electrical Code (NEC). Refer to the architect/engineer (A/E) for determination of hazardous classification.

12. Arms vault is constructed with duct passing through it. Duct is shown to be fitted with anti-intrusion bars, but removal of duct section also removes bars, leaving

an unprotected opening. Install bars which have structural integrity with wall. On future projects do not route duct work through arms vaults.

13. Convactor and piping in corridors of bachelor officers' quarters have been installed exposed. Drawings show the convectors exposed but the piping drops to the convectors are shown to be installed inside the wall. Exposed piping is unsightly. In addition, convector is connected to a 2-pipe system that will allow chilled water to enter convector causing condensation problems. Convactor is not needed in corridor. Recommend that convector be deleted. If this is unacceptable, replace with ceiling mounted fan coil unit.

14. There are no temperature gauges on the supply water lines off the pumps, nor at inlet and outlet water for boiler (specified for boiler). Provide temperature gauges at each pump discharge and at inlet and outlet water for boiler.

15. Air conditioning compressors and associated equipment are located below and behind the air handling unit. Access is limited by ducting. Maintainability is possible but restrictive. Access to air handling unit is also restrictive. Provide more mechanical room space during design stage to allow for maintainability of all equipment.

16. Power bus on bridge crane is open and is constructed of galvanized steel. Building is heavily ventilated by roof mounted exhaust fans. Operation of fans induces large quantities of salt-spray-laden air which adversely affects galvanized coating which, in turn, adversely affects electrical continuity between bus and contacts. Monitor condition of bus during warranty period. Specify compatible bus material on future contracts.

17. Contractor is in the process of driving test piles. However, contract documents did not prohibit procurement of remainder of piles until test pile results were attained. All piles are on site. Test pile results do not appear promising. In addition contractor was permitted to water jet pile for first 15 ft of depth. Water jetting reduces friction on pile. Purpose of test pile is to determine configuration of pile so that if a different configuration, such as a longer pile, is required the change can be made prior to procurement. In future, contract documents should prohibit procurement prior to completion of test piles. Deviation to allow water jetting should be conditional and not allowed if resistance is based on friction.

18. Personnel doors in maintenance bays are fitted with hasps and padlocks. This violates National Fire Protection Association (NFPA) 101, paragraph 5.2. An alternate means of escape is through the rollup door but operation of the door requires

continuous disengagement of motor clutch and manual door operation is too slow and cumbersome to comply with Chapter 5. In addition, paint spray area is viewed as hazardous in accordance with Chapter 28 and has only rollup door for egress. Provide other locking method than padlock and hasp. Provide a personnel door for paint spray area.

19. All areas containing munitions should be explosion proof. See NFPA 495-6-5.5.1-(g) and NEC 501. Install explosion-proof devices, light fixtures and boxes inside storage facility.

20. Light fixtures in missile storage area do not have guards. This is an area in which the light fixtures are subject to physical damage. Install guards on light fixtures at risk of physical damage.

21. Sequence of operation listed in specification Section 15508, paragraph 5.2 cannot be accomplished with equipment provided in the contract drawings. Ductwork is not provided with dampers to prevent halon from escaping. Doors are not provided with closers, gaskets, or threshold. Provide means to provide room sealing capability on room protected by halon.

22. Service entrance conduit at the power pole and the transformer pad is schedule 80 PVC 4 in. pipe. These are direct-buried. They should be steel or PVC encased in reinforced concrete duct bank. Reference NEC 710-3-(b) for voltages over 600 V. In future projects, use steel for direct-buried installations of electric lines over 600 V.

23. Several pump pits have the disconnect switch for the pump mounted down in the pit. Drain is to a gravel pit, by gravity. The pump, motor, and switch are subject to damage if the pit ever floods because the motor and switch are not of waterproof construction. Replace pump motor and disconnect switch with waterproof equipment or raise equipment above pit level.

24. Houses are not centrally air conditioned. For residents whose physicians prescribe an air conditioned environment, an electrical receptacle for window air conditioners is provided adjacent to selected windows. However, windows are horizontal sliding sash type and are not of a suitable size or type for the installation of window air conditioning units. Refer to user for direction. Windows in selected units can be replaced with a vertical sash type if user desires.

25. Drawings show no reinforcing in concrete encasement of PVC duct bank for electrical service. On all future projects, assure that concrete duct banks are concrete-reinforced.

26. The domestic hot water and hot water recirculation pumps are connected directly to the hot water piping without the use of flexible connections. This is in conformance with the drawings and specifications. Due to the physical size of the pumps and piping, recommend the use of flexible connections at the inlet and outlet of all pumps on this project to minimize sound and vibration transmission through the piping system.

27. Flexible spiral exhaust duct for the kitchen range was specified by the A/E and has been installed by the contractor. This duct can accumulate vast amounts of grease during use of the range, creating a fire hazard that will exist from now on. NFPA and all fire codes are violated by this design deficiency. Corrective action should be initiated immediately on this and any other completed buildings and additional buildings under this contract. A/E liability can be pursued. Note: this spiral duct should not be installed in any other project, which may have range hoods that attach to metal ducts for exhaust.

28. A sanitary PVC line has been installed, as designed, over the electrical panel in the mechanical equipment room. Any loss of water from the piping could result in damage/short out of the electrical panel. A shield between the piping and panel would prevent this event, since relocating the piping or panel would be expensive. Investigate to determine if the same requirement of NEC prohibits any water piping from being installed over electrical panels. Corrective action should be taken and future projects should prevent this condition from recurring.

29. The space under the stairway to the second floor has been specified as an enclosed storage area. Safety codes normally prevent the area being used for storage, since it can become a potential fire hazard. Check fire codes and with local authorities to determine if the fire hazard is enforced, then take the necessary corrective action. Future housing design should incorporate the restrictions for storage under stairways. Any other housing projects ongoing should also avoid this situation.

30. Flexible exhaust duct has been approved to be installed on the kitchen range hood. This type duct can accumulate grease and become an extreme fire hazard. Investigate this design condition and take corrective action of disallowing the flexible duct or change hoods to nonducted recirculating air type hood. Check all other division projects for a similar design deficiency.

31. No design requirement exists for draining the interior piping pit inside this facility, either by a gravity drain or sump pump. Action should be taken to determine the desired draining method for this deficiency.

32. Anchors for the hot water piping expansion loops have not been installed. The anchors are necessary to have an adequate operating heating system. Action should be taken to provide the anchors to meet heating system standards for completed expansion control. This condition exists on "All" division-wide projects included in this inspection team.

33. There is no vapor barrier and/or thermal insulation required for the exterior of the foundation walls. Engineering division should investigate this situation to determine moisture and freeze proof requirements for the foundation walls on this and all other division projects.

34. Battery charging room not sealed from adjacent rooms. Potential for explosion is high. Design normally isolates such rooms and includes explosion proof electrical fittings. Function of adjacent rooms compound the risks associated with the current design. Investigate the current design and determine any and all code violations. Have A/E provide designs to correct deficiencies.

35. No corrosion prevention chemical feed equipment was specified. Normally on recirculation systems of this magnitude, pot feeders or positive displacement pump systems are provided to scavenge dissolved oxygen and introduce sequestering agents. Have A/E provide design of equipment to properly protect recirculation system.

36. No power was planned on drawings for elevator.

37. Air handling equipment should be scheduled based on external static pressure and total static pressure that must be overcome, not solely by total static. Equipment could be selected that meets a total requirement but does not work because it cannot meet the external requirement. Specify equipment by both external and total static pressures.

38. The 4288 requires the resident engineer to approve all shop drawings. The district should follow the Engineering Regulation (ER) which requires that only extensions of design, critical materials and deviations will be reviewed by the government. Also use the correct 4288.

39. The designer did not coordinate with the city on their technical requirements for hookup of utilities to the local government's systems. Designer should coordinate with the city (local government) on their requirements for utility hookups on all future designs.

40. Unistrut pipe support system used to support copper refrigeration pipe. No isolation provided between clamp and pipe. A premanufactured isolator or felt isolation should be used between clamp and pipe. Specifications should be revised to address the use of unistrut type support systems.

41. This contract does not indicate how to construct proper condensate drain seals. As a result, improper seals have been provided. Seals need to be 2 in. greater in depth than the unit static pressure. They shall be constructed of a "U" bend with tees on the inlet and outlet. Tees to have tops capped. Specifications should include the guide specification paragraph addressing condensate drain seals.

42. Detail for fire dampers shows a flex connection between the wall sections. This method of installation appears to violate the Underwriter's Laboratories (UL) installation requirements for fire dampers. This fire damper installation method could cause the damper to fail and not provide the required protection. Fire dampers must be installed in accordance with the UL listing, NFPA, and Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

43. The paragraph for cold pipes does not allow the use of blanket inserts beneath PVC fitting covers. The paragraph for hot pipes allows the use of the inserts. Blankets were observed next to a cold pipe insulation operation beneath a raised floor on the second floor of this facility. The specifications should be revised to either allow or not allow the use of blanket inserts beneath PVC fitting covers for both hot and cold pipes. This should be consistent within a given specification.

44. The A/E designed a 4-wire smoke detector alarm system for installation. This system does not meet the fire department requirements for the facilities. There is a change order being processed to 10-wire heat detector system. The A/E should coordinate the design of these systems with the base fire department and base civil engineer (BCE). This should be done on all future contracts.

45. Details on sheet m-9 indicate how to support and protect pipe when using a trapeze of unistrut. This detail does not show using a 360-degree shield. Revise this detail to show the use of a 360-degree shield when using unistrut or "U" bolts to protect the entire vapor barrier jacket that could come in contact with the clamp.

46. Air handling unit fans should be rated on both external static pressure and maximum total static pressure, not only total static pressure. Specifying performance only on total static pressure could result in equipment being provided that cannot overcome the external static. Specify fan performance on external static and maximum total static.

47. Multi-zone unit #1 for this contract has been scheduled based only on a total static pressure. Air handling equipment should be rated both on external and maximum total static pressure. Specify unit performance on external and maximum total static pressure.

48. Lack of support of metal door frames in drywall causes doors to become misaligned after periodic use. Incorporate additional metal stud support in door frames.

49. Contract specifications are not prepared in Construction Specification Institute (CSI) format as required. This has been a requirement since 1976 and has been a repeat comment in previous inspection team evaluations. Assure all contracts are prepared in accordance with Engineering Regulation (ER) 1110-345-720.

50. Exterior classrooms have three different types of finishes in the same room. Precast panel attachments to the building structure are exposed to view. Concrete block walls and cast-in-place concrete are the other surfaces. All have different textures. The only requirement is to paint the surfaces. This does not end up giving you a finished effect. In future contracts, ensure structural attachments are concealed in finished work and pay better attention to interior finishes.

51. Light switches located on exterior of building at loading dock are not weather-proof. Provide weatherproof covers on exterior lighting switches.

52. Lighting fixtures installed under loading dock canopy are designed for recessing in a finished ceiling. Contract plans state that fixture is recessed type. Loading dock does not have a finished ceiling. Loading dock is a damp area per NEC. Fixture detail on plans does not require fixture to be listed for damp areas. Install fixture designed for surface mounting and one that is listed for damp areas.

53. Structural and architectural plans were not coordinated when designing the baptistery and its access. The stairs up to the baptistery pass through a wall which has a top that is only 10 ft - 2 in. to the bottom of the steel. The baptistery is 4 ft above finished floor, which, when the ceiling is installed, leaves an access opening of less than 6 ft. On future chapel jobs, coordinate features and lower pool to provide adequate access.

54. Specifications do not follow Corps of Engineers Guide Specification (CEGS) 10800. The specifications do not require the use of tamper proof fasteners. In future contracts, require A/E to use current guide specifications when preparing specifications.

55. When precast panels were set at corridor 130 facing courtyard 134, the weight of the panels caused the supporting beam, w16x36, to twist at the center causing the precast panels to come off the vertical. The beam had to have angle braces installed to brace it at the center to assure the precast panels remain vertical. In future contracts assure adequate support of beams to assure that they do not twist under loads imposed by precast panels attached to one side of the beam.

56. Interior electrical contract specifications section refers to the 1984 edition of the NEC. Contract specifications should have been revised to reference the 1987 NEC. Specification technical paragraphs should have been revised per current CEGS 16415.

57. The pass-through window in room G17 "classified mail" detail 12 on sheet a-74 shows an overhang of 2 ft - 4 in. This requires legs to assure stability of the counter top as its design makes it very heavy. Provide details for supports to assure stability of the counter top.

58. Replacement of the existing asbestos siding above the new glass block wall is not called for. This siding is in poor shape and does not blend in with the new exterior treatment of the building. The user will not be happy with the results in this area. In future contracts, assure the scope of the A/E design will result in a pleasing exterior architectural design

59. Outlet box extension rings are not flush with finish surface of gypsum wall board. Project specifications do not reflect requirement that box rings be flush with finish surface of gypsum wall board. Boxes are being installed per NEC (1/4 in. set back). Ensure that contract specifications are updated per latest CEGS.

60. Bull nosings on masonry block were called for on only a few exterior corners. There were many other exterior corners that should have had the bull nosing due to the heavy traffic and carts that will be used in the facility. In future contracts, require bull nose corners for all exterior corners subject to damage from equipment.

61. Specification section 10p2 did not require fasteners to be of the "tamper proof" or nonremovable type as required by CEGS 10160. Require the use of CEGS specifications when designing projects for the Army or Air Force.

62. Specifications permit use of exposed galvanized steel sheetmetal with prime and finish painting. This type material is not permitted by CEGS 07600 and the extra labor cost involved in initial surface treatment and continuing maintenance more than offset the cost of meeting present criteria. Future similar designs should follow CEGS criteria with respect to use of sheet metal material selection.

63. Single tube fluorescent lighting fixture mounted in the women's rest room on the fourth floor is not of the type requiring a forced movement along longitudinal axis of the lamp for insertion and removal of lamp. This requirement is in the guide specification but was not included in this project. In future specifications, include this requirement as per guide specifications.

64. New service entrance cable is # 2/0 aluminum. Existing panelboards are 100 amp with 100 amp main breakers. The new # 2/0 aluminum/service entrance cable will not physically connect to the existing panelboard main breaker terminals. Replace existing 100 amp main breakers with new 100 amp main breakers that will accept a # 2/0 aluminum conductor or replace panelboard interiors with new interior rated greater than or equal to 150 amp load and use 150 amp main breaker. Any of the main breakers used must also be capable of accepting aluminum/copper conductors.

65. Renovation project - third floor bathroom for handicapped. Commode has been installed for handicapped, but the sink remains for regular purpose. Install handicapped sink.

66. 12 in. water line will tie into existing asbestos line. This contradicts section 1a paragraph 29 which says ".....if it is determined that asbestos is present it shall be removed....." If this tie-in does not present a hazard as outlined above and removal of existing asbestos pipe is not necessary then compliance with paragraph 29 should be reviewed by district.

67. First floor (middle floor) - one ceiling exit lighting fixture mounted in the middle of the hallway is not located near exit. It is shown at this location in the contract drawings. Relocate exit lighting fixture approximately 25 ft north in hallway near north stairway exit.

68. Existing pipe is transite and has some percentage of asbestos. Contractor is cutting openings in this pipe to insert camera used to determine condition of the pipe prior to installing the required pipe lining. District should investigate and determine if special handling of transite pipe is required.

69. This is a design/build contract. Both the RFP and design/build drawings show the walls of an area accessed through a mosler vault door to be metal stud and drywall construction. This design makes no sense since security of this space is minimal when drywall construction is used.

70. Monthly evaluations of weather are not being done as required, nor quarterly modifications when the contractor is due time. Institute a district policy to implement monthly review of adverse weather as it affects each contract.

71. Specification does not require a sample masonry panel. Request through channels for guide specification change to require a sample masonry panel.

72. The submittal register does not indicate which items need to be for approval or for information only—policy is to require approval of only critical items. Submittal registers are not being maintained. The designer needs to indicate which submittals are for review and approval and which are for information only. Review submittal register prior to advertisement and reduce submittals for approval.

73. Modify files by: Categorizing changes and determining A/E responsibility, including miscellaneous commitment document in modification files, and preparation of prenegotiation objectives needs to be more timely.

74. Submittal register requires approval by government of many items which should be the responsibility of the contractor to assure they comply with the specifications. Guidance provided states that the government should only require submission of extensions of design, critical material, deviations and those involving equipment that must be checked for compatibility with an entire system.

75. Submittal register in the contract did not indicate in column "N" or "O" if the submittal is for government approval. In future contracts, the column "N" or "O" should be checked indicating if Corps approval is required or not.

76. Submittal register included in contract did not have column "N" or "O" filled out to indicated if submittal was for information or approval by the government. In future contracts, assure that the submittal register is prepared in accordance with ER 415-1-10 dated 17 October 1989, paragraph 8(a).

77. The contract contains the standard time extension for unusually severe weather. In addition, it contains an additional clause for lightning requirements and down time, which calls for five occurrences per month, 1 hour to all day with work restriction occurrences in addition to the weather clause. Include lightning considerations in the time extensions clause and include occurrences in the profile so the contractor can bid intelligently.

78. Project specifications should be updated prior to projects being advertised. Electrical section 16a references the 1984 edition of the NEC. Project was advertised

in 1989. Specifications should have been revised to reference the 1987 edition of the NEC.

79. This contract includes the "time extensions for unusually severe weather" profile with 37 calendar days anticipated severe for December through March. In addition, SC-43 indicates no work can be accomplished on grading subgrade, etc., during this period. District should resolve this ambiguity in the specifications since confusion in the documents could cause loss to the government.

80. 1. Lavatory drain traps have clean-outs in the restroom facility building which do not conform to the standard CEGS.
2. A protection ballard, similar to the one provided for the water stub-up, should be provided for the power pedestal at each trailer space.
3. There is only one clean-out provided for the entire sanitary system in the restroom facility building.
4. The exterior drinking fountains are not adequately supported to prevent damage from disconnection from the building.
5. The bottom panel of the exterior siding of the restroom facility building is below grade at points and is not treated to prevent rotting or termite damage.
Corrective action: engineering should review and take corrective action.

81. Contract did not require an environmental plan. A standard technical provision should be included in all contracts to address contractor's protection of the environment (water, air, soil, noise, etc.).

82. Emergency lights are required to be secured in case of seismic events. However, no details are shown on how to secure the fixtures nor is any reference made to the applicable publication. When seismic requirements are specified, either a detail or the applicable publications should be provided.

83. The electrical equipment room has insufficient space to provide working clearances as required by NFPA 70, Article 110-16. Future designs shall address referenced working clearance requirements.

84. Return air (R.A.) grills observed in room #5 were commercial grills with deflector blades to ceiling tiles. Use of ceiling grid lay-in perforated panels would be more appropriate. Additionally the 24x24 panels provide more free area for the R.A. to pass into the ceiling space. Face velocities on R.A. grills seem high. On future projects use standard (24x24) lay-in perforated ceiling panels for all R.A. openings in suspended ceilings. When size requirement is less than 24x24, use one panel. When requirement is greater than 24x24 use multiples of 24x24 panels.

85. Contract specifications allow use of plastic sleeves. Guide specifications paragraph 3.1.7.1 say plastic sleeves shall not be used. See CEGS 15400 (October 1989), Notice 2. Future designs should use guide specifications.

86. R.A. grills (rg-1)(sch on sheet m-5) need to be provided in each space to allow air to flow into ceiling plenums. Number of 2x2 panels should be determined based on R.A. quantities and face velocities of about 500 fpm over the free area. Install R.A. grills in ceilings.

87. The type "W" open fluorescent fixtures shown on the fixture schedule have been installed. However, the specified fixture is apparently available only with "Twistout" lampholders. This fixture does not conform to 16415 paragraph 24.2.4 which requires forced movement along the longitudinal axis of the lamp for insertion and removal of the lamp. Future designs should list open type fluorescent fixtures having lampholders conforming to 16415 paragraph 24.2.4.

88. The plan (drawing m-3/m-4) does not indicate a smoke detector in the supply system downstream of filter for a system of over 2000 cubic feet per minute (cfm) (air handling unit [AHU] has 27,000 cfm). The design requirements for smoke detectors should be checked in order to comply with the requirements of NFPA 90-a, paragraph 4-3.

89. No circuit indicated on electrical plans for hydraulic dock leveler. Dock leveler is specified in specification section 1116.2, paragraph 3.1 installation, indicated installation shall be as indicated. No electrical installation work is shown on plans. Issue contract modification if required to provide circuit for hydraulic dock leveler. Indicate controllers as specified by specification section 11162-3, paragraph 2.1.7; controls and safety switch (disconnecting means) per NEC Article 430, part h.

90. Fuel dispensing island (gasoline and diesel fuel) is located 16 ft - 0 in. (centerline) away from building NEC Article 514-2, Table 2 and Figure 1 indicate that 20 ft shall be used to delineate the hazardous area. Existing building has doors (openings) located within the 20 ft distance requiring existing electric work inside building that is within 20 ft distance to comply with NEC Article 501. Require engineering division to ensure that electrical work inside building complies with NEC Article 501 or relocate dispensing island 22 plus or minus from the building resident office has requested contractor to revise dispensing island shop drawing to place island 22 ft from building.

91. The 4288 submittal register is requiring the government to review and approve all submittals. This is in excess of the requirements of ER 415-1-10. The government

will review and approve "... extensions of design, critical materials, deviations or those involving equipment that must be checked for compatibility with the entire system..."

92. Specification section 08110 does not require exterior doors and frames to be galvanized. This is not in accordance with CEGS, which requires exterior doors and frames to be galvanized in wet areas.

93. Hollow metal door frames were grouted and then installed in CMU openings. Drawings require frames to be grouted but specifications are silent on installation. Specifications and drawings don't call for strap anchors. Shop drawings show anchors. Lay CMU up around door frames grouting full and installing strap anchors as you go.

94. Mechanical room does not have the proper ventilation to remove the hot air generated by the heating equipment/piping. Provide necessary air ventilation to protect electrical equipment and personnel during maintenance work.

95. Repetitive deficiency at projects west of Cascade Mountains is to not provide a grounding design for the electrical system as required by division, district, and the NEC.

96. Concrete foundation for new parking area lighting standard is only 5 in. above finished paved parking surface. Existing parking area lighting standards are installed on concrete foundations that are 24 in. plus or minus above finished paved surface. New parking area is an extension of the existing parking area. Concrete foundation design for lighting standards should be coordinated with existing foundation design and the user.

97. The design concrete repairs with shotcrete should not be applicable to areas such as abutments directly below bearing plates. The concrete condition at the top of piers and abutments is poor. Pumping action at bearing points might result in structural steel deck failures. The designer should obtain core samples of concrete below bearing plate locations. If the concrete strength is below the original strength, a replacement cast-in-place program for abutments should be initiated.

98. No transfer procedures have been established for this project. In addition, no draft 1354 has been prepared and no instructions given to project engineer. No warranty requirements have been established. Four and 9 month warranty inspections should be scheduled on accepted items. The district construction supervision should contact and advise the project engineer on procedures required.

99. No procedures have been established for the project engineer to review, process, and turn over O&M manuals for this project. District office should advise the project engineer on procedures for O&M manuals processing, etc.

100. The exhaust fan and unit heater fan motors are required to be explosion proof at certain locations by NEC. Uncertain if motors meet this requirement since they are inaccessible during this inspection. Inspect the motors for compliance and replace if necessary.

101. In the gas treatment building, stainless steel equipment and piping and carbon steel piping are not separated with dielectric fittings. This is normally required. Consider changing this to include dielectric fittings.

102. This project includes a new brick veneer enclosing creating a cavity exterior wall. New insulation is designed to be added inside the existing masonry wall: also brick expansion joints are a considerable distance from exterior corners. On future designs, consider attaching insulation on the outer face of the inner masonry wythe and include brick expansion joints 6 to 10 ft from exterior corners.

103. The plumbing inspected was not equipped with water hammer arrestors as required. Advise contractor that water hammer arrestors are required. Have engineering indicate required locations.

104. Some of the existing duct is uninsulated. Per this contract, duct will be enclosed behind a drop ceiling, whereas it was exposed before, which may allow conditions that would cause condensation to occur. Recommend that design personnel be consulted about adding insulation .

105. Commencement, prosecution, and completion of work calls for two phases: construction phase 550 days, and operation phase 365 days, respectively. Liquidated damages are \$1000 per day but are not specific as to which phase of the work it applies to. When separate phases of work are specified, separate liquidated damages should be designated for each phase.

106. The project is in seismic zone 1, which requires structural, mechanical, and electrical installations to include additionally designed materials and bracing for seismic restraint. This project specification does not require this provision. The district design/engineering division should investigate this requirement and develop a modification for this item, plus assure future projects at this location include seismic restraints.

107. No lightning protection system for the building is indicated on the drawings and none has been installed. Investigate to determine if lightning protection is needed for this facility.

108. No grounding of the fence surrounding the area has been provided. While this is not required by NEC or Engineer Manual (EM) 385-1-1, it may be required by the National Electric Safety Code (NESC). It is considered good practice to ground the fence in the vicinity of electrical crossings even when the crossings are underground. In this case, the permanent and temporary power crosses the fence and the temporary panels are right at the fence. Investigate and determine if grounding of the fence for protection against lightning and accidental energization is necessary.

109. There is no provision for handling rainwater or leakage from pipes and fittings that might accumulate in these pits. Recommend consulting with design personnel concerning providing a sump and sump pump with discharge to a proper location.

110. In various locations, carbon and stainless steel are connected (either bolted flange to flange or welded). This will cause premature failure of the carbon steel pipe. Advise the contractor that dielectric connectors are required.

111. Mechanical piping, electrical conduit, and other equipment are installed in same location as acoustical wall panels are to be installed, requiring either panel retrofit or omission of the panel where retrofit around other items cannot be accomplished. On future projects, conduit and piping should be installed above or below acoustical panel locations to minimize conflicts.

112. 12 in. dryer exhaust is 30 ft in length and has no provision for lint cleanout nor any sort of booster fan to ensure that lint from dryer does not precipitate to the duct creating a fire hazard. Project is design/construction. Require design/construct contractor to provide correction proposal for Corps of Engineering approval.

113. Documentation of initial inspections, preparatory inspections, and daily quality control (QC) activities does not contain definite information relative to contract requirements. No evidence of a deficiency tracking system was found. Provide on-site training and sufficient management emphasis to obtain conformance. Reuse area office quality assurance (QA) plan to address pre-award activities as well as deficiency tracking systems.

114. The 2-1/2 in. hose connections and gate valves are going to extend out into walk way and will be a safety hazard. Consult design personnel for solution.

115. Relief vents controlled by motorized dampers exhaust air into attic space during economizer cycle. No fire dampers are provided. Attic construction is combustible wood truss construction. Provide fire dampers by modification.

116. Fire protection plans are not clear. Symbol designations for rated walls in legends do not match wall designations on plans or the wall is depicted in such a way that the symbol cannot be matched with the legend. Also, ducts passing adjacent to each other through some walls have different kinds of protection (i.e., @cols bk and b14 one duct has fd and one has fsd) have on-site A/E thoroughly scrub fire protection plan to resolve inconsistencies. All ducts passing through rated walls should be checked.

117. No containment walls are being provided around the new generator day tanks in the central plant. Check NFPA for requirements.

118. Investigation of fire protection features is required. In some locations, fire-rated door frames are installed in walls that do not extend to the deck above. Thoroughly scrub plans to ensure that fire protection features are consistent with each other (i.e., rated walls should terminate at the deck above or at another rated ceiling structure and openings in walls should be consistent with ratings of the walls).

119. Elevator machine room is not provided with any climate control or ventilation. Hydraulic fluid reservoir for elevator is located in this room and will act as a heat sink for all the work performed by the hydraulic pump, potentially causing temperatures to rise above elevator control equipment limits. Refer to design A/E for resolution.

120. Seismic protection for mechanical electrical equipment shown, yet no specification for seismic protection has been included in the specifications. District office should determine if seismic protection is required for this project. Seismic protection guidance for electrical equipment should be requested from the Office of the Corps of Engineers (OCE).

121. Training center has a roof section that collects runoff from three sloped roof areas and is isolated from adjacent roof area that has roof drains. Consider providing roof drains within confined spaces when removed from primary areas of drain.

122. Waste oil tank details without spillage containment tank is installed on a concrete pad with no containment walls. Future designs should include containment in original plans to preclude modification required to correct the situation on this contract.

123. Location of crack control joints is confusing. Control joints in some walls seem to be well designed, whereas some walls have no crack control joints. Some joints do not run in straight line but have right or left jogs built in, posing a potential cracking of the brick face where joints do not run straight vertical. Investigate and take action as necessary.

124. Intake directory above exhaust fan discharge. There should be separation—at least fan should be on top and intake provided with a hood.

125. Some effort has been made to mitigate impact of exhaust/make-up air to kitchen areas; but use of make up air to hoods could decrease the amount of heated/cooled air that is removed from the space. Rethink hood designs and makeup/exhaust system concepts.

126. Expansion loops are shown on plans to penetrate a fire wall. Sleeves are provided; however, freedom of movement is restricted by this arrangement. Turn loop so that they are within the corridor envelope if sufficient space for required length is not available. Put loops closer together.

127. Specify "Detectape" in lieu of the "Markline" for underground utilities. This will provide extra protection by simply reflecting a signal off the solid foil code of the tape with a standard pipe cable detector. In future contracts, assure that the specifications required detectape.

128. Numerous cracks in concrete slab on metal decking. In approximately 60 ft of concrete deck no control joints are required by design. Review design and look to correct future projects.

129. Fuel storage area should be classified as hazardous location—class I, division 2. There is no requirement for electrical equipment and wiring (hazardous location). Comply with NEC 501.

130. Carpet has been installed despite heavy construction traffic, without any protection whatsoever. The amount of debris from ongoing work, equipment, materials, paint pails, etc. is extensive. Contract requires no soiling or damage protection while other work is going on. The guarantee clause requires contractor to replace damaged or stained carpet which only opens door to disputes between Corps and contractor. In future contracts, provide items requiring special protection for carpet if installed while substantial work is in progress. Suggest contracts should designate time appropriate for installing carpet.

131. Transitions in mechanical room are not in accordance with SMACNA standards. Designers should apply standards when developing equipment layouts. Details should be provided when space requirements are critical. Apply applicable standards.

132. There are numerous areas in the exterior and interior CMU where efflorescence is in evidence. Contract specifications do not require testing block, brick, mortar, etc. for efflorescence. District office to look into problems particularly in regard to section of individual material curing process utilized by manufacturer, effects storage, and construction practices.

133. Quality control requirements do not cover the requirements that the contractor's QC organization control the submittals. The submitted and approved QC plan does not address submittals. Revise QC requirements in future contracts to comply with ER 1180-1-6.

134. Submittals state that the contractor will be furnished a set of Engineering Form 4288 with the specifications. There was no submittal register provided by designer/engineer division on this contract as required by ER 415-1-10. On future contracts, assure that designer provides submittal register as required by ER 415-1-10.

135. Contractors proposed QC plan does not comply with ER 1180-1-6 requirements. The QC requirements in the contract do not require separate preparatory and initial inspection documentation. The sample QC report also does not mention type of inspection performed. Revise contractor QC requirements to comply with ER 1180-1-6 on future contracts

136. Job site is in seismic zone 2. There are no seismic requirements included in the contract specifications for mechanical and electrical systems. Modify contract to include all necessary seismic requirements for zone 2.

137. Horizontal header joints at the base of the check dam crib are open approximately 2 in. to 3 in. The only protection of the crib fill from scour action is a double layer of filter cloth. Consider filling these openings and header joints with concrete fill of equal strength as that of the crib wall members.

138. Concrete flood wall repairs under phase II work scope do not include many sections where deterioration is still visible. Task the designer of the proposed phase III contract with responsibility for reviewing the condition of existing walls and modifying the scope to include deterioration not included in phase II.

139. Flush valve stub-outs for water closets are not 39 in. above floor per specification. Guide specification footnotes to remove 39 in. requirement for facilities other than dormitories and unoccupied enlisted personnel housing. Delete 39 in. requirement and obtain credit.

140. Contract drawing shows feeder with the breaker set at 480 amp with no.4 equipment ground wire. The NEC table 250-94 requires a no. 2 equipment ground wire. Coordinate with the A/E and have the A/E check all other similar conditions. Comply with the NEC requirements.

141. Specification f-1 completion of the work calls for substantial completion of the library 4 months earlier than overall contract completion. Specification f-2 has liquidated damages against only the overall completion with no stated penalty for failure to provide the library on the earlier date. Future contracts requiring early completion of any significant feature of the work should include specific liquidated damages against that completion.

142. Not able to verify ground fault protection on the installed main switchgear. This is required per NEC Article 230-95. Engineering to verify compliance to NEC Article 230-95.

143. Numerous utilities of various types exist on the site of the roads which are not shown or only partially described (elevations, etc.). It is not clear if some of the information was available to the designer. Exercise more care during design/biddability, constructibility, and operability (BCO) review to locate and describe existing conditions and utilities.

144. The weather time extension clause included in the contract documents is incomplete. Only the first paragraph of the three paragraph clause required by ER 415-1-15 is printed in the contract documents. Future contracts should include all of the clause.

145. When the contracts for IDS are awarded for the combined chemistry lab and materials test building, assure that all design submittals are sent to the IDS-MCX for review. This comment references all future projects with IDS.

146. Fire protection materials were provided on the roof deck of mechanical room but not on structural columns or beams. The sprinkler system was provided for additional protection. It is important for the columns and beams to have fire protection as they are critical elements of the structural supports. Fire protection to be provided throughout the mechanical room.

147. No lightning protection was provided; however, numerous exhaust stacks (metal) rise above the roof line. Given the potential for catastrophic problems if chemical or biological agent is inadvertently released in the lab, it would appear prudent to provide lightning protection. Verify criteria and provide protection if remotest chance of lightning caused catastrophe exists.

148. Emergency light (self-contained battery unit) connected to a receptacle. Hard wire should be provided.

149. Battery/battery charger are located inside the UPS room. Battery and battery charger should be located in a separate room with proper ventilation.

150. No parapets or safety features were provided on the roof. This would create a safety problem for maintenance and repair. Incorporate parapet or other safety provision on the roof.

151. Many cracks appeared along the conduit line imbedded in slabs-on-grade. The concrete cover may not be sufficient. Verify design plans to find the causes of cracks.

152. There is no control joint provided in the CMU wall construction in excess of 60 to 80 ft. The wall is located inside the controlled environment (air conditioned). Look into the expansion-contraction aspects of the wall and verify if a joint is needed.

153. Section describes polyvinyl/plastic coating for electrical conduit underground and passing through slabs. This paragraph does not properly identify or relate to the conduit for exterior wiring which installs underground and up through concrete bases which support microwaves and cameras for the perimeter security system. Adequate tape of coating is not being provided for this conduit. Engineering should investigate this matter and develop a design model for correcting this specification and the job condition.

154. Contract requires contractor quality control system manager and staff of a minimum one full time person at job site at all times. System manager is only one at job site. Mechanical and electrical personnel are not part of the QC organization. Quality of electrical and mechanical work could suffer. The contractor should be required to provide mechanical and electrical QC while this work is going on. Current specifications are not explicit enough to ensure adequate quality control over mechanical and electrical work

155. Special clause 8 refers to ER 415-1-10 (15 May 1984). As with the Shemya contracts this reference is in error. Unlike Shemya, this contract incorporates a blank 4288 in the bid package. Shemya contracts contradict their special clause by incorporating a 4288 in the bid package wherein district has listed the required submittals. In future specify correct ER.

156. Submittals procedures are incorrect. Contract refers to ER 415-1-10 (15 May 1984). This has been superseded by ER dated 17 October 1989 which makes listing of all submittals Corps responsibility. Review current ER 415-1-10 and correct future. Review section 01340, technical provisions, vol ii, of contract specifications "Shop drawing submittals" to recognize extent of problem.

157. Both project office, BCE, and Shemya complain that specifications and plans for new work are not sent to them in time and in some cases not sent at all prior to advertising new work. District office should make effort to get review comments from Shemya people. Makes sense.

158. Precast panel design is unsatisfactory. Welded connections designed to resist shearforces are so located that the welding operation degrades the exterior surface of the concrete panels. Lack of repair will cause rust stains on panels. Require the A/E to provide a remedial solution to repair the exterior surfaces of the panels. Pursue A/E liability. During technical review of future projects ensure that this method of shear resistance is not used in precast panel design.

159. Heating, ventilating, and air conditioning (HVAC) ductwork will not fit below roof joists because ceiling is almost directly on joists. Because ducts are 14 in. the ducts will not fit through joists. 24 in. X 18 in. exhaust duct will not fit above ceiling. Lower 10 ft ceiling to 9 ft. This will revise height of movable partitions.

160. The plumbing vent from the first floor passes through the counter top and cabinet for the multicraft room. Precast concrete wall needs to be furred out to conceal piping.

161. A separate make-up air system is need to provide air to the kitchen exhaust hood when the exhaust fan will "steal" conditioned air from other areas of the building which will unbalance the HVAC system. Provide a separate air handler that will supply slightly tempered air either in the front edge of the hood or through a linear diffuser next to the hood. This air handler should be interlocked with the hood exhaust fan starter.

162. The mechanical room has no space heating system to prevent freezing. Although the boilers will generate sufficient heat within the room to prevent freezing. The SE

boilers are only used for standby purposes. Outside air (combustion air) intake hood. Provide motorized dampers on outside air intake (interlocked with boilers) and provide small space heater with thermostatic control set at 40 °F.

163. Various rooms have surface MTD conduits on walls. Since these walls are precast, lack of coordination led to this condition. Designs for future projects need to be reviewed for coordination between different disciplines.

164. Only duplex receptacles shown on one wall. Up to two receptacles may be required to fully utilize this room in a safe manner. Provide minimum one duplex receptacle per wall. Confer with using agency as to proper requirements for this room.

165. Rigid steel/intermediate metal conduit installed below slab-on-grade or underground is not shown to be field wrapped with 10-mil-thick pipe wrapping plastic. Contract specifications did not require this, although required by guide specifications. Where physically possible, install plastic wrap to concur with guide specifications, future projects should comply with guide specification requirements.

166. Concession stand CMU walls have 45 degree exterior corners in lieu of 90 degree corners (octagonal building). Block having a corner angle of 45/135 degree. To construct this corner without a continuous vertical mortar joints is not specified. Temperature variations cause this joint to act as a control which in turn causes the vertical joint to crack. Require the design A/E to provide a remedial solution. On future projects, ensure that details are provided for other than 90 degree corners. It is noted that Specification 04230 paragraph 7.7.3 requires whatever kinds of masonry shapes needed and that paragraph 13.2 requires bonded masonry corners, but it is felt that additional details should have been provided.

167. Design of gym and multipurpose areas are not consistent with good energy conservation measures and inconsistent with the architecture of the surrounding facilities. These rooms rise 68 ft in a single story and clearly dominate all of the surrounding area. Heating costs are expected to be excessive per square foot. This was discussed during design and no action was taken. Designs of this type do not make the Corps appear as prudent design/construction agents to our customers or the general public.

168. Nonload bearing CMU walls are not provided with restraints at the tops of the walls to prevent lateral displacement of the walls during seismic disturbances. Usual procedure is to provide spaced cup angles on both sides of walls at top of walls fastened to slab. Refer to structural section for determination if lateral restraints are required.

169. Design calls for placement of space heating convectors in shower room directly below shower head. This will cause corrosion to convectors. Place convector outside shower room.

170. Exhaust grill for shower room is located in the shower room. Because of an excessive amount of steam and moisture in this room, corrosion will result. Locate grill outside of shower room.

171. SC-36 time extensions for unusually severe weather refer to ER 415-1-15 (31 July 1987). This has been superseded by ER 415-1-15 (31 October 1989). The 1987 version deals in calendar days whereas the 1989 version uses work days. In future use correct ER.

172. Exposed wall and ceiling surfaces in the food preparation areas, kitchen areas, and dishwashing areas are listed in the finish schedule to be painted drywall. Criteria for dining facilities required these areas to be cement plaster surfaces. Refer to engineering division for appropriate action.

173. Structural steel tubing penetrate the main floor slab and are not separated (isolated) from the surrounding concrete by filler or joint material. Concrete is likely to crack at these locations and thereby crack the overlaying quarry tile finish. Details need to be shown on drawings. Requirement is included in specifications section 03300. Paragraph 12.2 shows detail. On future contracts, request corrective action on present contract by contractor.

174. Exhaust fan on the mezzanine is completely inaccessible for maintenance without climbing across the heat exchanger coil or its associated ductwork. This will damage this equipment. Provide a structural crossover so that this equipment may be accessed for maintenance.

175. Electrical room design does not provide clear work space to meet NEC table 110-16(a). Also two separate entrances to electrical room are not shown as required by NEC 110-16(c). I understand change order has been initiated to comply with this.

176. Contract specifications are using name brands or equal. The plans and specifications should state minimum technical requirements and not brand names or equal. This could lead to sole source. Follow the requirements of far 6.302.1.

177. The contract requires that government approve 100 percent of submittals. The government should only approve extensions of design, critical materials, deviations or those involving equipment that must be checked for compatibility with the entire system. ER 415-1-10, 17 October 1989.

178. Division/district employees involved in construction of a specific aspect of the work must be cautious in discussing matters with contractor personnel. Misunderstandings and inadvertent directives hamper contract management when such personnel do not involve the field office/representatives of the contracting officer in the communications loop. Work through field office staff when concerns over contractor operation compromises contract provisions/design intent. Do not issue directives without authorization.

179. The contract requires that the government approve 100 percent (all contracts looked at). The government should only approve extensions of design, critical materials, deviations, or those involving equipment that must be checked for compatibility with the entire system per ER 415-1-10, October 1989.

180. Contract drawings and specifications are using name brands or equal. The plans and specifications should state the minimum technical requirements and not brand names. This could lead to sole source. Follow Federal Acquisition Regulation (FAR) 6.302.1.

181. The specification section is using a number of outdated clauses (i.e., shop drawing submittal, weather clause, and etc.). In future contracts, use the proper clauses from ER 415-1-10 dated 17 October 1989 (new revision July 1991) and ER 415-1-15 dated 31 October 1989. (Note: shown new contract which has the present requirements.)

182. Waterstop as detailed cannot be installed without notching the waterstop to clear rebar. Designer should have required smaller waterstop or provided more cover on rebar. Future designs should consider this problem when sizing waterstop or detailing cover on rebar.

183. The ductwork as designed requires mixing air fittings and branch air takeoff fittings that produce poor airflow design. Provide a y-type air mixing fitting and a y-type branch takeoff fitting for proper air flow.

184. The proposed air intake through the existing mechanical room will not meet the air quality act as required. The fresh air intake must be through a duct or the intake relocated for clean fresh air.

185. As specified in Military Handbook (Mil Hdbk) 1008a, paragraph 4.3.4.1, halon is not allowed as a substitute for required fire protection systems. The halon system as the existing chemical biological facility was placed in manual only due to false dump risk. Thus, the facility has no automatic fire protection. Install sprinkler systems in facilities requiring fire protection as specified in Mil Hdbk 1008a.

186. Halon use only in aircraft hangar is a high risk and does not meet Mil Hdbk 1008a. Aqueous film-forming foam (AFFF) is required to fight JP-4 spill fires. The installed halon does not protect the aircraft when doors are open, which takes 2 minutes to close. The ultraviolet flame detectors used to operate the halon system have a history of false detection. Install AFFF systems in existing and future aircraft hangars. Use combination ultraviolet/infrared flame detectors to operate AFFF and CR halon systems. Reference AF Engineering Technical Letter (ETL) 90-09, 2 November 1990, and Mil Hdbk 1008a.

187. Ductwork drawings show duct with square radius elbows. Job specifications and CEGS require long radius elbows to be installed whenever possible. This comment covers all designs for Pacific Ocean Division, Japan District. Provide design drawings with long radius elbows as required per CEGS and SMACNA.

188. Seismic protection is not provided on Government of Japan projects, fire protection systems. Install seismic protection on fire protection system piping as specified in NFPA-13 and CEGS 15501 or update Specification 15300.

189. Duct design drawings and contractor installation has square elbows with turning vanes. Specifications require long radius elbows whenever possible. Design drawings should show long radius elbows as required in specifications. Ductwork with square elbows per trade coordination should be long radius elbows.

190. Submittal register included in the specifications is not filled out to indicate contractor or government approval. Per ER 415-1-10 included submittal register on future contracts should show information only or government approval.

191. Contract drawings require the use of extractors to control air flow supply. Contract drawings also indicate square elbows with turning vanes in lieu of long radius elbows as required in specification 15804. Install 45 degrees branch takeoff ducts with volume control dampers in lieu of square "t" connections with extractors. The drawings should indicate long radius elbows and contractor should install them as required.

192. Pump motors in equipment room are not in line of sight of motor control center. Disconnects in motor control center are not capable of being locked off. Install disconnects at all motors that are not within 50 ft and in sight of motor control center.

193. Fusible disconnects are not provided for chillers. Chiller nameplate calls out specific fuse size. Provide fusible protection for chillers per NEC 1987 section 440-21.

194. Contract drawing requires the fire sprinkler design to be classified as high piled storage class IV and ordinary class III. This is a design conflict. High piled storage can not be classified as ordinary group III hazard. High piled storage must be designed for NFPA 231 or 231c for rack storage. The contract must reference NFPA 231 and 13, for proper installation requirements.

195. Contract specification 15501 paragraph 4.1 requires the design to meet NFPA 13. The storage area must also meet NFPA 231 as indicated on contract drawing m-2. NFPA 231 is listed in paragraph 1.9, but not referenced in this general requirements of the specification. The storage facility must be designed and installed per NFPA 231 and 13. The commodity classification must be provided and sprinkler riser detail should be included in the drawings. Since there is no post indicator valve required in the utility plan, provide a shut off valve in the riser.

196. Sheet m-3 of the contract drawings shows adjustable extractors at duct branch takeoffs. Contract specification 15804 requires the air distribution system to meet SMCNA, which recommends that extractors should not be used. Delete the extractors and require 45 degree branch takeoffs with volume dampers as required by SMCNA.

197. The contract drawings do not indicate fire protection in the loading dock area. Provide sprinkler protection, as required in NFPA 13, to the loading dock area of the warehouse.

198. The contract requires fire sprinkler protection classified to ordinary hazard per NFPA 13, which limits storage to 12 ft. The storage facility will allow storage above 12 ft. Design storage facilities according to NFPA 231 and 231c so storage can be over 12 ft.

199. Contract does not require any environmental plan. All contracts should require the contractor to comply with the host nation requirements or at the minimum U.S. requirements if the host nation does not have any. This is required to help protect U.S. personnel as well as the host nation environment. Include minimum requirements in all new contracts.

200. The amount of resteel (#11 bars) in some of the columns took up so much room that the concrete with 3/4 in. maximum size aggregate could not be placed properly and vibrators cannot be inserted to the bottom for consolidation. Review size of resteel in relation to column size to assure that concrete can be placed properly.

201. Section 22 states "certificates of compliance shall be submitted in accordance with special contract requirements." It does not say on what materials we want certification on. We need it on the structural steel bolts and nuts as well as on the structural steel itself. In future contracts specifically list what needs certificates of compliance to include high strength bolts and nuts.

202. There is no detail requiring control joint/isolation joint between column and foundation wall at the pump house chlorination facility. As a result the wall cracked at its midpoint between columns. Assure that this isolation detailing is required on future designs.

203. The structural steel bracing is crossing in front of the air conditioning opening, creating a possible conflict. This was noticed also at another site where bracing is in conflict with a window. In future contracts, coordinate bracing with building openings to avoid conflicts.

204. Specifications call for a 3-ply built-up roof system. However, because the top felt is a stone-embedded felt, a 3-ply system cannot be used. Review roof system utilized to assure satisfactory system is in place, and assure that error is not repeated.

205. No submittal register was included with the contract plans and specifications as is required by ER 415-1-10. Ensure that all new contract plans and specifications contain a filled in submittal register.

206. The QC requirements included in the contract specifications do not contain the requirement that the contractor include a list of definable features of work as is required by ER 1180-1-6. In future contracts, require contractor to include definable features of work in his quality control plan in accordance with ER 1180-1- 6.

207. The contract did not contain a special clause dealing with time extensions for unusually severe weather as is required by ER 415-1-15. Ensure that future contracts include the clause required by ER 415-1-15.

208. Contract specifications do not require sealing of the mechanical fasteners for the duct insulation on HVAC ducts. This is required by the guide specifications. Include requirement in future contracts.

209. No filters were provided in the exhaust system of dryers to remove lint. The built-in filters in the dryer are not sufficient to remove all the lint. Provide a filter for the exhaust system.

210. Plumbing vent stacks do not penetrate through the roof, but stop at the attic floor. Even though the attic is well ventilated, vents should continue through roof. Request reconsideration and modify contract if necessary.

211. Contract specifications are not prepared in the CSI format as required by ER 1110-345-720. Be sure that all future contracts are prepared in CSI format.

212. The submittal register was not included in the contract specifications as required by ER 415-1-10. In future contracts, require the A/E to prepare submittal register and include in construction contract.

213. The ends of the standing seam metal roof are open and can allow driven rain and snow to get under the metal decking. Review design and modify design to assure that the ends are closed to assure that water cannot enter through the ends.

214. There was no fire detection specified in the crawl space under the new roof on the terminal. This is required by AF fire protection standards. Review and provide proper protection for the space under the new roof.

215. The special contract clause requirements for "contractor quality control" do not comply with ER 1180-1-6. They do not require the contractor to provide a list of definable features of work and it does not require the QC manager to report to the home office and not be under the control of the project engineer or superintendent. Revise the specification to comply with ER 1180-1-6 on all future contracts.

216. Contract drawings do not require control joints at column/masonry intersections. Also there are no control joints at same location in interior plaster and exterior stucco. Review requirements for control joints and install them if considered necessary. Ensure that this issue is addressed in future designs.

217. The contract special provisions did not reference European Division Manual (EUDM) 385-1-1 or require the contractor to comply with it. In future direct contracts, be sure to include the requirements to comply with EUDM 385-1-1 in regard to safety.

218. The box wall section is 20-24 ft tall. Due to hydraulic considerations no caged safety ladder system was used. Access ladders are recessed to reduce hydraulic losses. However, when using a ladder, there is a safety risk the Occupational Safety and

Health Administration does not allow. Provide an additional rail where a safety belt is attached. This can be recessed. This eliminates U.S. Army Corps of Engineers (USACE) design liability as safety device was provided. Too late to incorporate on this project, but should be considered on all future projects.

219. Gaging station and manhole adjustment details—manholes have individual foot/hand hold steps. Individual steps have come loose more than a bolted ladder. Use bolted ladders for manholes deeper than 8-10 ft. For less than 8-10 ft depth, allow maintenance crew to use portable ladders.

220. The Corps criteria for design and specification of "standing seam metal roofs" has been found to be deficient. ETL 1110-9-12(FR) dated 21 March 1991 has corrected these deficiencies. However, the designs of the standing seam metal roofs for these buildings were completed prior to the issuance of the new criteria. Two dining facilities also have standing seam metal roofs. The current USACE guidance does not require a contract modification be issued on ongoing construction contracts. However, South Pacific Division, Los Angeles District (SPL) should be aware of the new criteria and incorporate in all future designs.

221. HVAC units in each bedroom require HVAC air opening under both windows. A structural column between windows will not allow opening. Design requires correction.

222. The partitions for toilets in both men's and women's restrooms are unstable to the point that constant maintenance and replacement will be required. Additional supports to the ceiling or otherwise will prevent destruction of these partitions. This design deficiency should be investigated and corrected before occupancy.

223. The restroom chromium hot water piping requires insulation; however, the wrap around type insulation used can will be easily removed causing constant maintenance and replacement. Cellular or fiberglass split and glued type insulation would provide better protection and last much longer.

224. No provisions were required by designer for protective guards (wire type or otherwise) for the wall mounted thermostats, emergency lights, or return air grill in the gymnasium. Ball hitting any one of these could damage or destroy them.

225. Insulation sample requirement in guide specification was edited out of contract specification. On future projects with significant amounts of insulation, make sure the sample is not omitted.

226. Rear entrance does not have any concrete stoop or walk. Front entrance has walk and stoop where parking is located. Rear entrance is toward family housing and tennis courts. Youths do not normally drive and at least 50 percent of the traffic will be from rear entrance. Soil will be tracked into building. Correct deficiency. Respond as to how SPL will correct.

227. No sheet flow drainage diversion is provided over building entrances and mechanical/electrical equipment. Also in areas other than entrances and mechanical/electrical equipment, no ground treatment (i.e., aggregate blanket) is provided to keep soil from eroding where sheet flow hits ground after leaving roof. Correct deficiency. Respond as to how SPL will correct.

228. Pass-through window has loose frame which can cause window chipping or children getting their hand cut on window frame. Details on plans are inadequate. Replace pass-through window with approved (UL rated?) window assembly.

229. Emergency lighting light sets are mounted too low for proper illumination of paths of egress in gym. In all cases they are also susceptible to physical damage because of low height and lack of protection (wire cage). Light sets behind bleachers are in way of spectators. Relocate light sets behind bleachers. Provide protection of all light set in gym.

230. 500kVa 12kV/277/480V transformer is located in what appears to be a parking area behind the building (pad mounted) without any protection from physical contact. Likewise, 480V switchgear is located adjacent to rear entrance. Both switchgear and transformer are an attractive nuisance for users of this facility. Building transfer switch is accessible to general public. Building roof drains on switchgear. Provide physical protection to limit access to electrical equipment to qualified personnel.

231. Gym light fixtures - these fixtures should have lenses or wire guards to protect lamps. Provide protection for lamp.

232. Currently installed hanging lamps (incandescent type) have inverted open bowls. This is a potential fire hazard because youths will use the bowl as "basketball catcher." The youths will crumple paper and other trash and try to ring the lamp shield. Provide nylon type netting (open) to cover the open bowl.

233. Currently the gym has metal hailide units for general lighting and standby emergency light. Problem: if momentary power outage occurs, the emergency light will go on; however, when the power returns, the emergency lights will go off and leave the gym in total darkness for approximately 3 to 10 minutes. Provide two fluorescent

units or incandescent or halogen lights which would come on immediately and give minimum safety level lighting until the metal halide units restart. Provide timeout sequence for instant on lighting to save incandescent lighting.

234. Specification section 16415, paragraph 10.1 requires 20 amp receptacles. This is too expensive and 15 amp should have been specified. Specify 15 amp receptacles in the future.

235. Currently, the cooling fan mounting brackets are directly supported by transformer coils. This type of physical mounting is inadequate and will cause premature failure of transformer cooling assembly during seismic event and vibrations. Provide manufacturer's recommended mounting for fan assembly that will meet seismic requirement.

236. All HVAC units have wooden (4 in. X 12 in.) beams as HVAC unit support with inadequate seismic tie down. As installed, the HVAC will not take lateral motion. Note: drawing detail on mounting and specification 15200 does not agree in designing for seismic zone 4 application. Replace wooden support with HVAC manufacturer's recommended HVAC to concrete pad spacer which would meet the seismic zone application.

237. Guide specification 16415 requires boxes installed in metal stud construction to be supported by more than side-attachment to a stud. Support of opposite side is also required. A tab brace used in some applications is inadequate. Technical Provision (TP) 16311 was intended to incorporate the necessary CEGS 16415 requirements; however, this particular provision was left out. Correct future designs.

238. Contract drawings show a 8 ft - 6 in. vertical clearance of 34.5kV terminator (transition from overhead to underground) above ground. This is the bare minimum NESC clearance for this installation. Based on other dimensions of these switching stations, this dimension could have been made greater, thereby ensuring a higher degree of safety at no added cost. In future designs, whenever safety clearances can be increased without substantial cost increase, do so.

239. Gas valve shows no requirement for box at main gas valve near street so valve will be buried. Provide valve box.

240. Clean out types 5, 7, 9, etc. are located in the same area. Type 5 is shown as "load bearing," but the other types are not. They should either be all load bearing or all nonload bearing. Analyze load bearing requirements and revise drawings for consistency.

241. The fire sprinkler post indicator valve (PIV) is located about 15 ft from the building. There appears to be room to move the valves to the 40-foot required distance. Move the PIV to code distance unless space does not exist.

242. Bench excavation has "very high percentage of fractured rock". No rock bolting nor shotcrete has been specified for benches. Based on field observations and location adjacent to fault, a division and cecw technical re-evaluation should be conducted to validate cespl design based on in situ conditions. CESPED-ED-G and CECW-EG should inspect the site with district to verify that rock bolting/shotcrete or other surface treatment is not required.

243. Existing power house falls below the 100 year pool elevation. Owner has not yet been directed to remove. Old transformers have pcbs and can contaminate ground water if allowed to remain. Construction contract will be impacted as no date has been given to power house owner. Mandate the removal of all hazardous materials from power house. Provide date as to when power house and flume have to be relocated so construction will not be impacted.

244. The exterior steel door and frame are not required to be galvanized. All exterior doors and frames should be galvanized to extend their life. The type of hinges for that door was not specified. The contract specifications should be more specific and for exterior hinges they should require nonrising pins for added security. In future contracts be sure to adequately specify door, frame and hinges.

245. Regulation ER 415-1-10 states "Designer will prepare a list of submittals required for each contract." Contract cites FAR 52.236.4003 "Engineering form 4288 has been partially completed---," lists only 11 items, and leaves most of listing for the contractor. This is not the intent of either the regulation or the FAR. Majority of items at least should be listed by the Corps.

246. The contract did not call for patching of defects and tie holes within 24 hours of removal of forms. The patching and repair of form tie holes produces a better finish when accomplished as soon as possible after removal of forms as possible. Curing is more uniform and apt to be accomplished also. In future contracts consider requiring the contractor to patch as soon after form removal as possible but at least within 24 hours.

247. Bids were opened without certification. Paragraph 7 of ER 415-1-11 requires certification by chiefs of engineering and construction of incorporation of BCO comments. Chief of contracting ensures that the certification has been made before he goes out to bid. If the certification is not there, then a memo for record by the

contracting officer must be put in the file to explain why the certifications were not done. Revise standing operating procedure to comply with ER to prevent a reoccurrence of this problem.

248. Preaction system riser diagram does not conform to figure a3-9.2 of NFPA 13. Also check valve in fire department connection line shown with wrong flow direction. Check on conformance of riser configuration with NFPA 13 and Major Army Command (MACOM) (authority having jurisdiction) requirements (if any); correct diagram. Correct check valve flow direction.

249. Drawings indicate an apparent interference between the bridge crane travel and the unit heaters. Check that unit heaters are available that can be installed to clear the bridge crane's requirements.

250. Site plan appears to indicate that new 750kVa transformer primary winding is to be wye-connected. However, Specifications 16402 states that primary winding should be delta-connected. Resolve discrepancy in transformer specifications

251. Fuel oil supply and return lines from storage tank run underground to building; type-k copper tubing. Check if fuel oil lines require secondary containment/leak detection per Environmental Protection Agency (EPA) and/or MACOM; provide if required.

252. Lighting plan shows exit sign to be non-electric type. No wiring is required for this type of fixture. Also, OCE has not approved use of this type of fixture—please check. Provide electric-operated, explosion-proof exit sign if non-electric exit sign is disallowed by OCE.

253. Single line diagram shows an interlock to be installed between existing main distribution panel (MDP) and new MDP4 but does not indicate how this interlock is to operate. Clarify interlocking requirements. Note that NEC only requires that a sign be posted adjacent to each panel indicating that there is more than one service to building.

254. Lightning protection air terminal installation details, appears to indicate that terminals will penetrate roof. There is great concern that this type of installation will compromise integrity of roof. Revise details such that air terminals are installed on top or sides of roof.

255. Small classroom with two windows. One window is located so that when the movable partition opens and is in its storage position it covers approximately half of

the window. Reviewers should be alert for this situation on future designs. Nothing can be done to correct the problem on this facility.

256. Drawings and specifications did not make any provision to close or conceal the open joint between columns and exterior precast. User is aware of this and correction is not high on their priority list. Funds are limited. Reviewers should be alert for this situation on future designs. In view of the user's desires, do nothing to correct this problem.

257. PVC pipe indicated for condensate drain lines for computer room A/C units; lines are within the underfloor supply air plenum. PVC pipe/materials may not be allowed in air plenums per NFPA (90a) and/or Corps' design criteria. Check if PVC pipe/material conforms to smoke development and/or flammability requirements for material in air plenums.

258. No water hammer arrestors shown on plumbing systems (plans or isometrics) in toilet areas. Show locations and sizes of arrestors.

259. Total flooding halon 1301 systems indicated for installation in avionics rooms. Per ETL 1110-3-426 (23 March 1990), halon 1301 systems are not allowed except in spaces where strategically important functions vital to national defense are conducted and continuous operation of the equipment is absolutely necessary to ongoing strategic military operations. Delete system unless it qualifies for exception; provide substitute fire protection system.

260. Sizes of fuse links in fused cutouts on riser poles are not indicated on drawings or specifications. Provide information on fuse link sizes.

261. Wiring of new loadbreak switch appears to be improperly phased. Wiring should be phase a-b-c, left-to-right or right-to-left, as required to match phase sequence of existing distribution system.

262. Mechanical room for classroom buildings without toilet (classroom, north-west end) does not allow maintenance access for suspended AHU. Mechanical plans show layout for mechanical room with toilet, but not for mechanical room without toilet. Ninety degree rotation of mechanical room results in new equipment layout that varies greatly from the typical layout shown. On future projects, show layouts for each mechanical rooms' configuration to ensure that accessibility for maintenance exists.

263. Drawing shows weep holes located below grade. This will hinder drainage of moisture from the cavity and could cause problems due to moisture accumulation. A

better design would be to locate weep holes above finish grade. Contract shows weep-openings above finish grade. Future designs should avoid locating weep holes below grade. Reviewers should be alert to this situation during reviews. Consideration should be given to relocating weep holes in walls not yet constructed.

264. Both CDCs show booster water heaters to supply 180 °F hot water to triple compartment sinks. Per message R191600Z MAR 90, chlorine bleach can be used for sanitizing in lieu of booster heaters and other chemicals at triple compartment sinks. Check if deletion from project at this stage is appropriate and delete if feasible.

265. Pad mounted transformer is located too close to louvered openings in west side of building. Transformer should be located per criteria spelled out in Mil Hdbk 1008.

266. Pad mounted transformers generally located too close to building openings. Transformers should be located as per Mil Hdbk 1008.

267. Conflict between existing ducts and foundation for hanger doors has caused delay and additional costs. Ducts were shown in plan but not in profile. Problem could have been avoided by better coordination between structural and electrical during design. Could have been caught during site plan-in-hand review. Improve coordination during design reviews should be alert to these types of conflicts. Site plan-in-hand reviews should consider profile as well as plan aspects of existing utilities.

268. Emergency light fixtures are shown connected to a different lighting panel from the high bay lighting fixtures in violation of NEC. Should be connected to the same lighting panel per NEC 700-12(f).

269. Exhaust fan motors are specified as 120V, 1-phase in mechanical specifications but electrical drawings show 480V, 3-phase starters for these motors. It appears that there was no coordination between mechanical and electrical designers. A cost analysis should be prepared to determine whether it would be more cost effective to replace motors or motor starters to correct this problem.

270. The following items of plumbing specifications have not been coordinated on contract specifications and plans, which creates confusion between field personnel and the contractor.

1. Vertical piping on urinal and commode should require a support.
2. The vacuum breaker needed on water line in the wash room is not specified.
3. The lavatory drain trap includes a cleanout, which is not standard in CEGS.
4. Do write any item in the specifications that is not required on the project (i.e., heat tape is not needed for hot or cold water piping).

The design division should make thorough final reviews of plans and specifications to assure items not applicable to the specific project are omitted or written in more detail to clarify the requirement.

271. The exterior vertical wood siding - on guard house - extends into the ground. This wood will rot in a short time. Should be approximately 3 in. above grade. Specify wood siding to terminate above grade to prevent rotting. Cut off existing wood siding above grade to prevent rotting.

272. The picnic tables and benches constructed of treated southern pine as specified. Note a number of splits, splinters, and rough edges that would pose potential hazard to the user, primarily children. Use a different material, such as rubber coated steel pipes, aluminum or plastic to avoid or mitigate this potential problem.

273. Gusset plates for roof truss were bolted without washers. The plans indicated bolts with washers at connections with columns, but are apparently silent on the roof truss connections. Review if washers are required on roof truss connections and install washers, if required.

274. The contractor quality control requirements contained in the specifications did not require him to submit a list of definable features of work as required by ER 1180-1-6. On future contracts assure QC specifications comply with ER 1180-1-6 and CEGS 01440.

275. Contractor quality control specifications are not prepared in accordance with CEGS 01440. ER 1180-1-6 dated 1 April 1991 now requires the use of CEGS 01440 for quality control specifications. On future contracts comply with ER 1180-1-6.

276. The plans detail the expansion joint between the precast plank, but expansion joint does not extend up through the 2 in. to 3 in. concrete topping. A sawed joint was installed that was about 1/4 in. wide and 1/2 in. deep. This is not an expansion joint. Any expansion or movement will cause concrete to spall. Review design and install expansion joints as needed.

277. Noted two aluminum ladders with broken hand rails (i.e., the top 3 ft of one side broke off). Informed that ladder broke when boats tied off to ladder. Aluminum ladders appear to be inadequate considering the location and potential use or abuse, and the rungs on the ladders are smooth. This is not covered in the contract. There is a potential hazard considering location and use. Noted that the f and w added slip resistant tape to the ladder they use. Future projects should consider a stronger

design for ladders to minimize or eliminate breakage. And all ladder rungs should be made slip resistant for safety to the public.

278. Reference section 16415, page 10, paragraph 3.7 "lamps and fixtures." This specification does not adequately describe electrical lighting for the rail lights. No designation has been included to require waterproof material (i.e., fixtures and tubes). The location and application on this project is not as should be. Design section should, in the future, make a more concerted effort to specify electrical light and fixtures more applicable for the wet and corrosive condition that exists on this project.

279. The design effort for the subject facility was assigned as a workorder to an open end contract between a local architect and the Directorate of Public Works. In turn, the architect hired an electrical consultant. The resultant design required considerable modification during construction to satisfy the local utility (Consolidated Edison) prior to connecting power to the substation. Special design efforts such as this should be separate contracts including coordination with utilities.

280. The outgoing 4160 V feeders lack indicator lights. As a result, the system operators are not aware of the status of the feeders. The maintenance of the system takes much longer than would be necessary if there were indicator lights. Recommend that indicator lights be added on all the 4160 V feeders to indicate the line status; either on or off.

281. Ammeters were not provided for the 4160 V distribution feeders in the secondary switchgear. Although this aspect of the design is in accordance with the minimum requirements of Table 4-2 of Technical Manual (TM) 5-811-1, paragraph 4-8 a.(4) requires additional metering to meet the needs of the utility or user. In this case, the user needs ammeters for those feeders which are to be loop fed. It is critical in every substation design that the specific requirements of the user or utility be incorporated into the contract documents.

282. TP 16 b-6.2 requires conduit entrances into buildings to be sealed to prevent the entrance of moisture. However, this problem also occurs with electrical equipment installed outdoors connected to an underground conduit. The guide specification should be changed to require sealing of any underground conduit entering electrical equipment.

283. Although the contract called for test procedures and reports to be submitted and approved, the specific items to be included were not identified. In addition, some capabilities of the substation could not be readily demonstrated due to the lack of loads. This situation placed an unfair burden on the construction personnel to

approve/assist in developing test procedures, a burden they may not have been qualified to assume. Design guidance must be issued to provide more detailed commissioning criteria in the appropriate specifications and design manuals. The designer should develop a test plan for inclusion in the contract documents.

284. Control rooms should be designed to provide the room temperature and humidity at an acceptable level for the equipment installed. State in the criteria to the designer to provide an environment suitable for equipment installed using power ventilators with insect screens or air-conditioning as required for the climate.

285. Power system coordination is needed. The design of an electrical system must include power system coordination to prevent unnecessary operation of power equipment protective devices. The initial coordination shall be general in nature. Upon completion of construction, coordination shall be re-evaluated to assure that all protective devices are well coordinated.

286. TP 16 a-2.10 calls for the contractor to provide qualified personnel to install, test, and start up the substation. The contracting officer is to approve these personnel. There is no language addressing particular qualifications and no language addressing the responsibility for inter-contractor work. Guidance should be revised to include specific qualifications for specialized subcontractors and a single qualified party must be responsible for the overall performance of the system.

287. There is no specification in CEGS 16311 for auxiliary building to house public service meters, relaying equipment, batteries, and other equipment. Add this requirement to CEGS 16311.

288. Electrical one line diagrams are the "road maps" of operating an electrical system. It is imperative that these one-line diagrams be maintained accurately at all times. While the as-built drawing may reflect the construction system, this information is not transferred to the system one-line diagrams. It will be necessary to have the one-line diagrams updated as a line item on the 1391.

289. Sheet E 10.1 calls for each transformer to be 10/12.5 mVa. TP 16 a-12 indicates that the first rating is outside air and the second rating is two-stage forced air. Since the second rating is 25 percent higher than the first, a lot of forced air would be expected. However only one fan was provided and this fan covers only a small portion of the surface area. In addition, one fan cannot be two stage (unless it is two speed). Check with the contractor or supplier to assure that the transformer can meet its required 12.5 mva rating.

290. Technical Specification 02685 does not require piping to be installed in accordance with NFPA 54 as does Technical Specification 15488. Make sure that NFPA 54 is discussed at the preparatory inspection, and that all work complies with this standard.

291. Top of a duct for a floor outlet box is 2.5 in. deep in a 4 in. slab. The duct is 1.25 in. deep. This means that the cover under the duct is only 0.25 in. This is not sufficient to prevent moisture intrusion. Obtain a design clarification sketch.

292. NFPA 90a requires smoke detectors over 2000 cfm (supply). Specifications do not cover smoke detectors. Drawings do not indicate smoke detectors on control diagrams or notes, mechanical legend, or ladder diagram. Duct, A/C accessories do show detectors, but no description. Provide complete design as required by NFPA.

293. Reference drawings were made by a lighting manufacturer and included in the contract the drawings show aiming points, illumination levels, model numbers, and manufacturer's name. Regulations do not permit identification of proprietary products unless sole source procurement has been approved. Provide designs that give specific descriptions of features without using proprietary names.

294. The 416V/240V feeder to a light pole has a riser diagram showing the neutral grounded at the pole. Since the neutral is grounded at the transformer and there is no disconnect at the pole, the neutral is grounded twice. This is a violation of NEC 250-23(a). Delete second grounding of neutral.

295. Drawing c-5a shows the oil immersed transformer about 5 ft away from the brigade command and control facility. Mil Hdbk-1008a requires the transformer to be located at least 25 ft away from the building, unless a fire exposure protection method is used (a stub-up with conductors has been installed). Confirm the exact location of the transformer to be installed. If the clearance is less than 25 ft, refer to Mil Hdbk-1008a if an exception is applicable. If not, adjust the stub-up transformer location.

296. Section 5 on sheet a-2 shows 4 in. CMU below windows. There is no indication on the "S" drawings that 4 in. CMU was considered by the structural engineer. Four in. CMU cannot be used in structural walls in any seismic zone. This detail should be checked for structural adequacy.

297. Drawing plate no. e9 indicates "all materials shown and intended for use are to be as manufactured by Thompson Lightning Protection Inc...". Although another product will be installed, the note identifies a proprietary product. This is not

permitted by DOD and USACE procurement procedures, unless sole source approval is obtained. Notify designer of the above comment and ensure future designs comply with the above requirement.

298. Contract drawing a2.1, sheet 13 and a2.4, sheet 16, door d11 in break room 420 calls for overhead coiling door with fusible link. This is a life safety hazard. There is no other exit from this room. Engineering must redesign this room to provide a means of egress. A modification will be required.

299. Contract drawing a2.1, sheet 13 and a2.4, sheet 16 on window detail d11 requires a 4 ft x 4 ft 20-minute rated 1/4 in. wire glazing in a 1-hour rated corridor which will have a glazed opening of 1849 sq in. NFPA 80 paragraph 1-7.3 requires that for 1/2 and 1/3 hour, maximum area of individual exposed lites equals 1296 sq in. Design personnel should avoid this error in future contracts.

300. Specification paragraph 15400-3.1 prohibits hubless piping below slabs. Specification paragraph 13083-3.3.1 allows no-hub fittings for underground waste piping. Clarify requirement and implement in future contracts.

301. Specification paragraph 15250 and contract drawings do not require insulation of condensate drain lines. These lines were not insulated by contractor. Also, conflict in specifications on definition of high density inserts. Section 15400 says 8 pounds per cubic foot (pcf), and none needed on pipe < 2 in. Section 15250 says 9 pcf and required at every shield. Issue model to provide for insulation of condensate drain lines. Clarify specifications on definition and requirement for high density inserts.

302. Drawing a-1, sheet 13 indicates a fire rated corridor with 20-minute fire rated solid core doors installed in nonrated frames. This does not comply with NFPA 80 or NFPA 101. Engineering should review the design and determine what changes will meet NFPA 80 and NFPA 101.

303. A fire alarm control panel with integral annunciator is being installed in a room accessible only from an interior corridor. A remote annunciator should be installed as close as practicable to the building entrance so that arriving firemen can quickly locate the fire. Confirm annunciator location with local fire protection engineer and fire fighting personnel.

304. Drawing plate e-4 grounding of neutral at generator. Since auto transfer switch does not switch the neutral, the generator is not a separately derived system, so that the neutral is not to be grounded at the generator (NEC 250-5(d)). Notify engineering of comment and comply with NEC.

305. The isolated ground conductors are connected to the standard ground terminal strip, which is not isolated at the panel board. Also, the isolated ground and standard ground conductors are shown to be connected by a jumper between the isolated and standard receptacles. Confirm design scope of work to isolate the ground terminal strip at the panel board and isolate the grounding conductors from the standard grounding conductors.

306. A graphic annunciator for the fire alarm system is not being provided. The Air Force normally requires one when four or more zones are provided (confirm with Air Force Regulation 88-15 on number of zones). Confirm design scope of work.

307. Handicapped water closets are provided. However, handicapped lavatories are not specified. Modify contract to provide handicapped lavatories, and ensure that future jobs include complete handicap access.

308. Extension cords used throughout the area were on the ground and not protected from foot traffic, etc as required by EM 385-1-1 paragraph 15.a.07. Comply with safety provision. Also, remove damaged cords from jobsite.

309. No ladder climbing safety device on fixed ladders except for lock chambers. Install fall protection on all fixed ladders more than 20 ft in height.

310. Drawing e-21 of the telephone riser requires a 1-1/4 in. conduit for 3 to 8 pair telephone cables. The 3/4 in., 1 in., and 1-1/4 in. conduit system for three outlets is the design for a key system that uses 25 pair cables. The 1-1/4 in. conduit is oversized and should be reduced. For future projects, reduce size of the conduits to match cables being installed. For this project, terminate conduits above suspended ceiling and install plenum type cables (if required) above ceiling.

311. Cannot find technical requirements for the 8 pair telephone cables shown on drawing e-21. Add technical requirements for cables.

312. Drawing e-23 the detail for low voltage power and data cable in same trench does not show depth for trench. Show depth of trench as 56 in.

313. There are no details on plans and specifications on how to install the 10 in. x 10 in. wood posts for the retaining wall. The holes are augured. No specifications or details on backfilling between post and outside of hole. Provide details on backfilling.

314. Section 04200 of contract specifications does not comply with the guide specification 04200. The specifications allow the use of truss type reinforcement

instead of ladder type required by the guide specifications. Require all new specifications to comply with guide specifications.

315. Specification section 07240, paragraph 16, exterior insulation and finish system, allows manufacturer to specify accessories such as trim, edging, etc. Details on drawing do not show any accessories such as corner beads. Concrete finish without exterior corner beads is subject to damage from troops, maintenance personnel. Pure zinc is also recommended in lieu of galvanized steel for accessories. Refer to A/E for review of specifications.

316. The specifications require the contractor to perform original and final surveys for pay purposes. This is not in accordance with FAR 52.236-16 or ER 1130-2-307 unless it is approved at division level. The contract documents should provide for government surveys of both original and final profiles for pay purposes.

317. Environmental protection requires continuous drain including water quality protection. Limited and inadequate drainage facility appears evident. Note that when minimal embankment is breached, drainage will be affecting residential development. Improve drainage and assure that residential development will not be affected due to construction. Option is to review and reduce environmental protection section requirements.

318. The structural steel beam used as the support for the sewer line is not protected from unauthorized access. Modify design to protect steel beam from unauthorized access.

319. The notice to proceed for this job was issued on 6 January 1992. The contract specifies a duration of 180 days. It is not possible to do much exterior work in the area of the job until almost 15 April - 1 May. With a 4 July 1992 completion date, this actually gives less than 2 months in which to do the work. This is not long enough. The duration of the job must be coordinated with the construction restrictions of the area in which the work must be done. In future contracts, do not issue Notice to Proceed until a date closer to when work could be expected to begin.

320. The following information was not shown on contract drawings nor provided in the specifications: conduit sizes, cable sizes, cable termination, and type of telephone jacks. Provide a telephone riser diagram and show cable and conduit sizes, and provide specifications on cable termination and telephone jacks.

321. No signal line filters are shown at entry into secure area. Recommend filtering communication signals into the secure area. This includes telephone and fire alarm signals. Also provide specifications on the filters.

322. Paragraph 3.19 in section 16415 references the contract drawings for further information. However this information is not shown on drawings. Coordinate contract drawings with paragraph 3.19 in section 16415.

323. The contract does not designate a billing office for purposes of the Prompt Payment Act. Be sure that the contract designates a billing office for payment purposes.

324. Majority of floor slabs have developed cracks across the length of the slab. The cracking may be caused by a combination of 2 in. diameter tie rods with a 1/2 in. thick pipe insulation sleeve, thickness of slab as they slope to drains and tank/equipment loads. Future designs should consider the high potential for cracking with this system and place control joints where required. Consider possible impacts of accidental spillage of contaminated liquids and take required corrective measures.

325. Facility labs have exit doors without panic hardware, emergency eye washes, or fire alarm pull stations. Designer should review these rooms to ensure and confirm they are in compliance with applicable codes.

326. There are only four masonry control joints on the north and south sides of the building which is 214 ft long. There are none called for on the east and west sides which are 87 ft long. This is not in compliance with Guide Specification 04200 and TM requirements. In future contracts, require A/E to use CEGS 04200 and TM requirements for masonry design.

327. Acrylic skylights do not meet Class A fire ratings for exit hallways. Verify Class A fire rating for skylights and revise skylights to class a on future designs if needed.

328. The golf course clubhouse specifications are silent on seismic requirements. Site is in seismic zone 1. Add seismic requirements.

329. Disconnect switches for welding machine receptacles are not accessible from floor level. The switches are mounted at a height of approximately 12 ft from the floor. Quick disconnect capability accessible from the floor is necessary. See NEC Articles 2306-70(a) and 230-72(c). Provide access to and means to disconnect switches from floor level.

330. Outdoor wall mounted lighting fixtures were on during bright day light. All outdoor lights should be controlled by photoelectric cells. Install photoelectric cell to control all outdoor lights. If such a cell is already installed it should be checked for proper operation. Light should not be on in daylight.

331. Exit signs are not provided over exit doors from shops (oxy/acetylene, metal, arc welding, etc.) to hallway. Exit signs are provided only over doors which exit to the outside of the building. See life safety code NFPA 101-1988 (ANSI) section 5-11. Install exit signs over all doors that exit shops into hallways.

332. Masonry cavity wall has through wall flashing which returns down the brick outside face about 2 in. This installation is somewhat unsightly and does not match the existing structure. Future designs consider using flashing terminated within the brick mortar joint for a more aesthetic appearance.

333. Fire protection system plans and specifications are silent on back flow preventer on water supply line to alarm check valve. Air Force Manual (AFM) 88-15 requires sprinkler system installations be so equipped. Future designs and on this contract comply with AFM 88-15.

334. Child activity area without an exit leading directly to the exterior as required. Replace window with a door.

335. There is a seismic specification but no seismic zone details shown. This facility is in seismic zone 1. In the future ensure that all contracts are complete in all aspects. Detail drawings need to be developed.

336. Building shall have outdoor, wall mounted high pressure sodium (hps) perimeter lighting. The design does not show any wall mounted perimeter lights on any outside walls. Install wall mounted hps perimeter lighting on the building controlled by photo-electric cells.

337. The contract specifications for this contract do not provide a fire stop. Fire stops should be provided to prevent smoke migration. Provide fire stops.

338. AHU-1 is installed on vibration isolators. Refrigerant piping to AHU is installed rigid with no flexible connections provided. Specifications state to be installed where indicated. Plans were not fully developed. Installation is in seismic zone 1. Investigate and take needed corrective action to ensure an adequate installation for equipment mounted on vibration isolators

339. Light fixtures in bathrooms are on the same circuit as ground fault circuit interrupter (GFCI) outlets controlled by a toggle switch. Lights in the bathroom should be controlled only by a toggle switch (wall mounted) and not go out when GFCI is tripped. If possible rewire the fixture circuit to control the light from the wall mounted switch only. Do not have both the switch and the GFCI inactivate the lights.

340. QA reports nos. 1 through 210 contain very little, if any, pertinent information on inspection phases, work in progress, safety, etc. Also, reports nos. 1 through 10 show the invitation for bid number instead of the contract number. Monitor QA reports and provide instruction to construction representatives in proper reporting.

341. This contract was awarded without actual agreements with local sponsor and utility companies on relocation dates for all utility lines. Estimated completed date of utility relocation was 1 June 1992, which was the date in bid documents when the contractor would have full access to site. This has been changed by letter to contractor to 1 September 1992 asking for his cost proposal, which has now been changed with a letter to 1 November 1992. In all future contracts rights of entry, relocation of all utility systems should be complete or lock in date with a liquidated damage clause to the government. If the contract dates are not met.

342. Amendments are issued so that you are required to cut and paste the changes into the bid documents. The amendments should re-issue the whole page with the area highlighted that is changed.

343. Drop metal ceiling panels may rust in high humidity areas (shower areas in toilet). Design should have put in nonrusting ceiling panel (e.g., nonmetallic, or if metallic, coating should be for high humidity areas).

344. Section 2.02 paragraph g has been changed to require a single wall tank and subparagraph 4.a provides one 22-in. diameter access manway. Vehicle fueling systems require double wall tanks with 2 to 24 in. minimum diameter access for tanks over 4,000 gallons.

345. No vibration isolators have been installed under the air compressor. No flexible connectors have been installed in the pumps suction or discharge piping. Neither of these items are required in the contract specifications. The district engineering division should follow the CEGS in requiring vibration isolators/flexible connector installations.

346. Re-entrant corners in the slab-on-grade do not have two #4 tie bars as required by TM 5-809. The slab has only a few cracks, but further cracking could occur as the

slab continues to shrink and goes through the first heating and cooling season. Use extracts from TM 5-809 crack control measures in future request for proposal specifications.

347. Paragraph 1.3.1.4 states that fire protection systems are to be installed in accordance with NFPA, Appendix A, as specified in section C-15501 sprinkler systems. NFPA does not require a flexible coupling in the piping where it enters the building (i.e., through the floor or footing). Investigate the NFPA seismic restraint requirements versus TM 5-809-10 and American Society of Testing Materials applicable to require the same seismic restraints for sprinkler systems as all other water piping, etc.

348. The existing fence had to be partially removed and will be replaced later and extended around the project. The fence is not grounded. This condition exists at several other sites included in this overall project. The project specifications do not require existing and new fence grounding. Power lines are over and near the perimeter fences. The district electrical design section should initiate a modification to include fence grounding to meet NEC requirements for this project.

349. Design drawings of the A/E do not show installation details, location of equipment devices, etc. Better design review of A/E work in the area of specifications, drawings, and coordination between drawings and specifications is needed. Also centers of expertise should be asked to provide design review.

350. The contract specifications for this project does not require vertical wall ladders. Previous contracts on the Mill Creek improvements do have ladders on vertical walls which are 20 ft high and do not require safety cages at the top. Future contracts should require safety cages for ladders installed on vertical walls over 20 ft high.

351. Reference drawing a-4, east elevation. Ladders are installed at eave side of the building where ice, in winter, will make ladders unsafe and possibly unusable. In the future, locate ladders at the gable end of the building.

352. Specifications require control joints as indicated on the drawings; however, no details are shown. The contractor is installing the joints as agreed upon in the field. These joints should not be designed in the field. The designer should indicate the location of these joints on the drawings and further should check these field locations to ensure effectiveness.

353. The contract requires two coats of latex paint on interior masonry walls and two coats of an epoxy paint on interior walls in bathrooms. No filler coat is specified.

Without a filler, coat walls are rough and unsightly. Specify a latex block filler before applying finish paint coats.

354. Ductwork arrangements shown, model P-00016, and physical installation reflect transition angles steeper than recommended by SMACNA (sheet m-3). The model made conditions worse, especially on the fan discharge. Return/outside air (O.A.) intake needs attention—R.A. has turning vanes and O.A. has none in summer mode. Improve arrangement geometry and coordinate HVAC space requirements with structure.

355. Both leaves of the door that meet to make the closure contain concrete counterweights that are not mentioned in the contract specifications or drawings, nor is the design of the doors included in the submittals on file in the resident office. Clarify.

356. Attention needs to be directed to seismic requirements specified for this facility which is in zone 1. There is no seismic detail in plans. Ensure that seismic protection is installed.

357. Sheet number c16, detail b1, shows the top of curb flush with the walkway. Actual construction has the curbing extended above the walkway. Verify that actual construction meets the intent of the design.

358. The contract specifications require drips to be provided where indicated. Plastic pipe 1 in. size gas distribution main is being installed without drips at all low points. Drips are indicated on the drawings where gas is supplied to gas fired appliances. No profile shown on plans for gas main. Investigate and take corrective action as required. Does the valve engineering proposal that was approved remove the requirement for drips in gas main?

359. Section 15501 of the specification cites section 02713 for underground water supply piping for sprinkler systems. There is no specification section 02713 in the contract. Keep the specification cross references accurate.

360. Room 043 is approximately 10 ft 7 in. long with a single door. The enclosed switchboard with a 1200 a main breaker (800at) is 10 ft 4 in. long and 24 in. deep. The switchboard will not fit in the room and if it did it would not comply with NEC 110-16(c). Room 043 should be widened and lengthened to provide 6 ft in front of the switchboard and length to allow installation and provide space to mount panels "M" and "D." Comment on transom 16415-1 indicates problem noted.

361. Reference drawing m-13 of this contract. Plan shows riser diagram without a backflow preventer. AFM 88-15 requires back flow preventers to be installed (see paragraph 15-3f-40). Provide backflow preventer per AFM 88-15 requirements. Also see Mil Hdbk 1008 "Basic design standards" and AF ETL 85- 21.

362. The bunker oil fired boiler located presently in the materials storage area is equipped with a low water cutoff only. AFM 88-15 requires a combination boiler water feeder and a low water cutoff be provided. Meet the requirements of AFM 88-15.

363. This facility is located in seismic zone 4. There is a specification for seismic installations. However there are no details in the contract plans. Seismic bracing was being installed on piping systems. Ensure that seismic details are included in all future contract plans. BCO review comments should deal with inclusion of seismic details.

364. The mechanical system installation of piping and tanks for diesel and mogas is being done in a creditable manner. No vapor recovery is required for mogas system installation in the specifications for this installation. Note: the installed dispensing pumps cannot be used for flushing. See specification paragraph 20, section 13215. Ensure a separate pump is used to accomplish flushing.

365. A type 215 fixture is specified to be installed in the washroom. A vapor tight fixture should be provided in the wash area.

366. The exhaust fan (item 25) is not shown on electrical drawing e-5, sheet 101. Coordinate the mechanical and electrical drawings. Use the same symbols or item numbers. For example: Do not use SF-3 for item number 23.

367. The feeder to the lift station (EM 11-22) is 20a; 2 phase, 120/208 V. The motors in the lift station are 3 phase, 230/460 V. Also there is a panelboard to service other items. The 208-V feeder cannot be used to power a 230 V motor. Have the contractor furnish 200 V motor and 3-phase power.

368. Seismic drawing m-33, "Details for seismic bracing. These "funny papers" do not show or tell a contractor any essentials for construction purposes. Seismic details should reveal factual data for installation requirements.

369. The steam pressure reducing station shown on m-28 shows pressure relief valve (PRV) to be 2000 lb steam and a 2-in. bypass line with a globe valve. The pipe size of the bypass cannot exceed the capacity of the approved PRV. See American Society of

Mechanical Engineering pressure code piping manual. Comply with the code requirements.

370. Copper piping and plumbing system specification states that piping larger than 2-1/2 in. shall use multiflame torches to make up joints. The hot water heating specification is silent in this respect. Clean up the specifications to ensure that workmanship requirements are the same when copper piping is used in the plumbing system or the heating system.

371. There are no seismic details shown on the contract plans. Ensure that all bidding documents have adequate seismic details shown since all installations in Alaska are in seismic zone 4.

372. Boiler detail shown on m-9 shows a low water cutoff for the boiler. The specification also calls for a low water cutoff only. AFM 88-15 requires boiler installations to be equipped with a combination boiler water feeder and low water cutoff. This appears to be a common shortcoming in Alaska district that should be corrected to meet Air Force requirements.

373. The boiler for this installation is placed in the mechanical room showing evidence of rust which apparently occurred during shipment to the job site. Word received is that the contractor has been denied payment for materials received. This leaves the question as to why the unit was installed in the equipment room after a preparatory inspection was made of materials received. Since the equipment was not properly protected from weather during shipment, suggest it be replaced. Only visible rust will be removed and surfaces reconditioned as repair is done at the job site.

374. Per the plans, the two downspout nozzles for the rainwater leaders on the back side of the building are located 10 ft above grade. Unsightly stains have already developed on the exterior wall finish where water falls down the wall. Consider attaching a bronze drip chain from the downspout nozzle to the splash block. It could be anchored to the splash block to direct water away from the wall.

375. This project consists of extensive alteration of an existing club and additions which approximately double the size. New portions are roofed with a new roofing system, but the existing roof is labeled "to remain." Consideration is being given and design accomplished to re-roof the existing building by change. Extensive alteration work is already done in both areas. Design of existing re-roof work should be accomplished prior to bid/proposal. Such vital work should be at least an alternate item so the advantages of competitive bids/proposals can be realized. Work by change order can only be more expensive.

376. There are no flexible connections being provided or installed at building expansion joints for water piping and duct work. The sprinkler piping system is being installed correctly with flexible joints where sprinkler piping crosses building expansion joints. Provide flexible connections where water pipes and ducts cross expansion joints as well as sprinkler pipes.

377. The diagonal bracing members were not isolated from the slab on grade at locations where the column support pedestals were isolated. The diagonal bracing could damage the slab when these members are loaded by gravity or lateral (wind or seismic) structural loads. When column pedestals and bases are isolated from the slab-on-grade, all diagonal bracing attached to the column should also be isolated.

378. Reference drawing m-2. The designer has referenced brand names in mechanical equipment list. Comply with ER 1110-345-100.

379. The steam pressure reducing station installed has 8 in. steam supply with a 3 in. sarco pressure reducing valve, a 2 in. pressure reducing valve, and 8 in. globe valve. A bypass around reducing valves shall not be greater than the capacity of the installed pressure reducing valves. See the American Standard Code for pressure piping. Ensure that installation is in conformance with code requirements. Plans show combined capacity of 15450 lb/hr. Shop drawings were not available for pressure reducing valves.

380. The contract plans show no details for seismic installation requirements. There is a section 15200 in the contract specifications. Seismic details should accompany the plans. Ensure that all future contracts show adequate seismic details.

381. Recessed fixtures are not supported to building structure or joist. No detail is shown on drawing for fixture support. Fixtures are supported by grid with clips without any hangers or rods to building joist. Specification does not clarify for fixture support. Ceiling grid is supported by wires to bar joists. Provide proper support for recessed fixture. Mount to building structure. Provide detail on drawing and specify clearly in the specification.

382. Counterpoise for different buildings shows a symbol which is a static ground rod test well. These symbols are shown for all ground rod locations. This is an overdesign. Test well ground rod is only used for the discharge of static electricity for mobile equipment, vehicle, trucks, etc. and does not have to be installed at every ground rod. Normal ground rods should have been shown with one or two test wells as required for static discharge. This is not cost effective. Correct design and show test well static ground rod as needed.

383. The contract requires the use of an i-j method per section h, paragraph 19. The contractor is currently using Primavera (precedence method) which has been accepted by the government, although it is in violation of the contract specifications. Since this method is becoming more widely used, include this method in the specifications as an option. Include a requirement for the contractor to provide training to Quality Assurance Representatives on this method on the project site.

384. Paragraph 3.2.3, surface-smoothness determinations, states that the entire area shall be tested for smoothness in both the longitudinal and transverse direction for both the runways and taxiways every 5 ft or less. Review the need for testing every 5 ft or less on the taxiways. Possibly revise to allow sample tests every 25 ft plus across each joint or use a vehicle and drive along to test for smoothness.

385. Lightning arrestors are not provided in the primary compartment of the pad mounted main transformer. See district design manual for the requirement. See CEGS 16402, paragraph 11, transformer station. Provide lightning arrestor within transformer primary compartment per specifications.

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